



# SKYWARN Spotter Training

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*[www.weather.gov/gray](http://www.weather.gov/gray)*

# Overview

- National Weather Service Definitions and Forecasting Tools
- Weather Spotters... Why they're important?
- Thunderstorms
- Tornadoes
- Flash Flooding
- Storm Safety

# NWS Mission

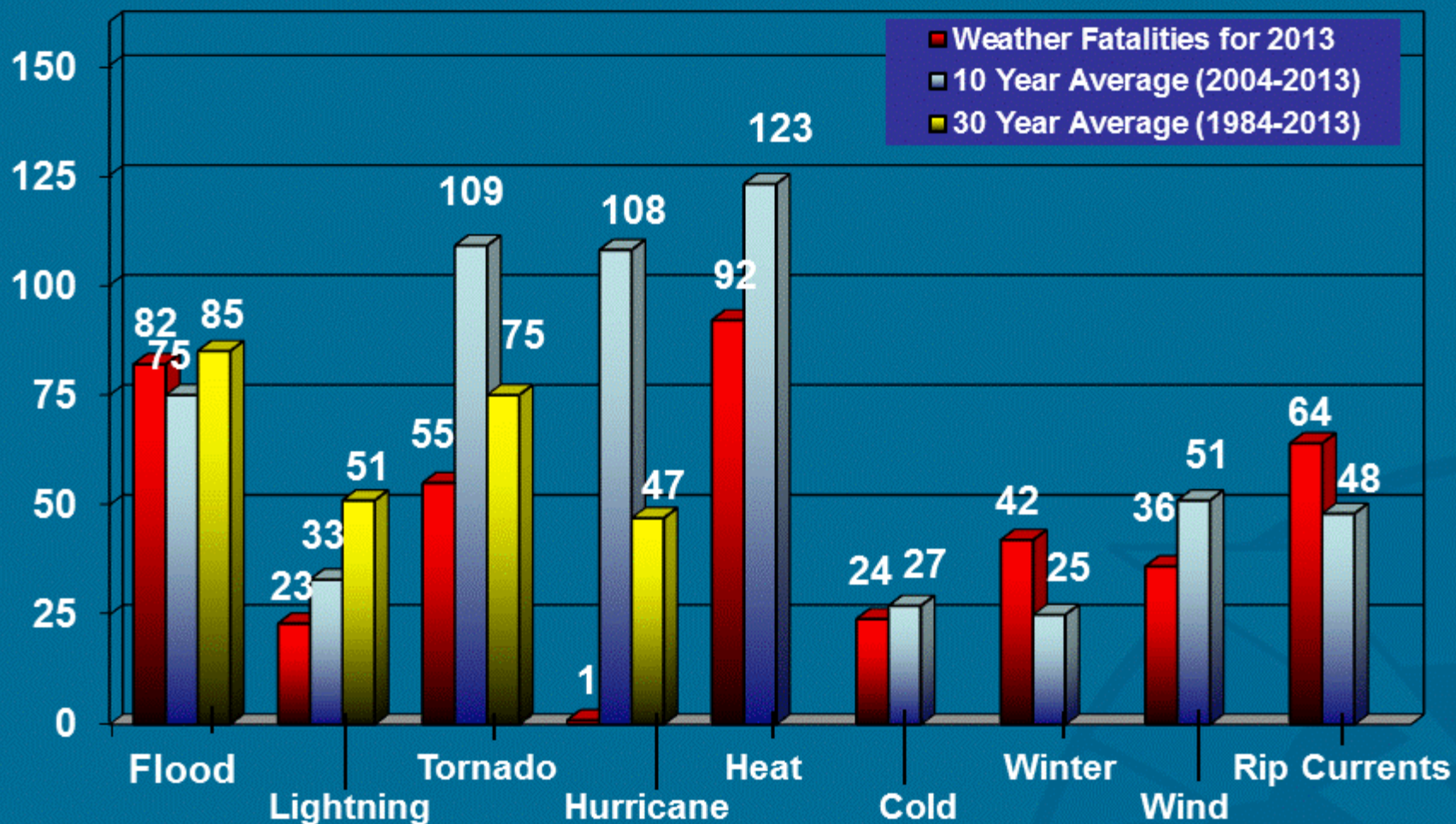
“To protect the lives and property of the citizens of the United States...”

- Watches and Warnings
- Outreach and Training



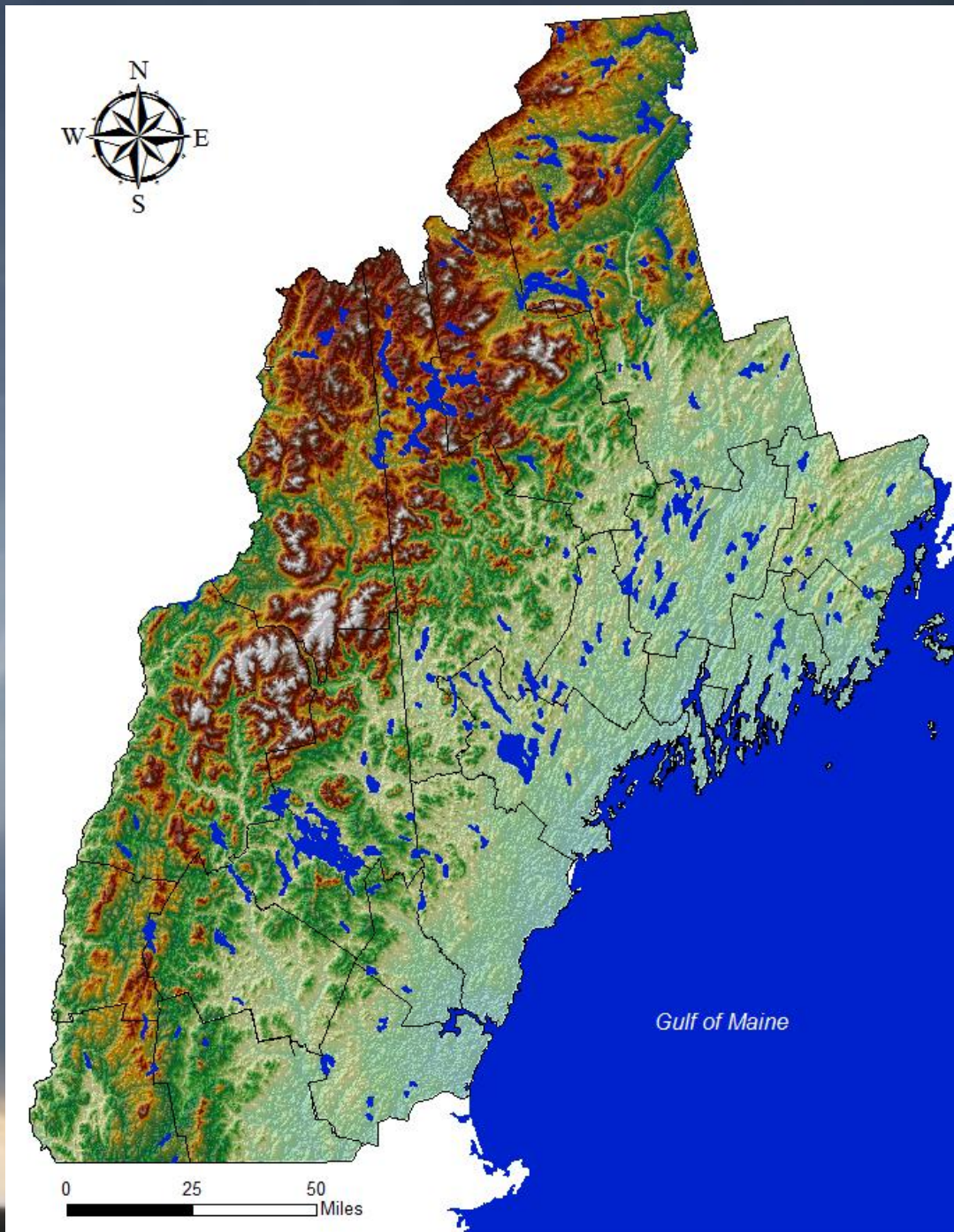


# Weather Fatalities





# NWS Gray County Warning Area



# Basic Definitions

- **WATCH** – conditions are favorable for severe weather to develop. Valid 4-6 hours. Contains several counties.
- **WARNING** – severe weather has been visually observed or detected on radar. Valid usually 1 hour or less, issued on a storm-by-storm basis.
- **STATEMENT** – provides follow-up information to a warning which is in effect.



# Basic Definitions

- **TORNADO** – a violently rotating column of air, attached to a thunderstorm, and in contact with the ground.
- **SEVERE THUNDERSTORM** – a thunderstorm which produces hail 1 inch diameter, and/or wind gusts 58 mph (50 knots) or stronger.
- **FLASH FLOOD** – a rapid rise in water, usually during or after a period of heavy rain.



# Tools for Detecting Storms

- Observations
- Computer models
- Satellite
- Radar
- Storm spotters

Copyright S. Hanes



# Observations

- We take many measurements of the atmosphere:



# Weather Balloons

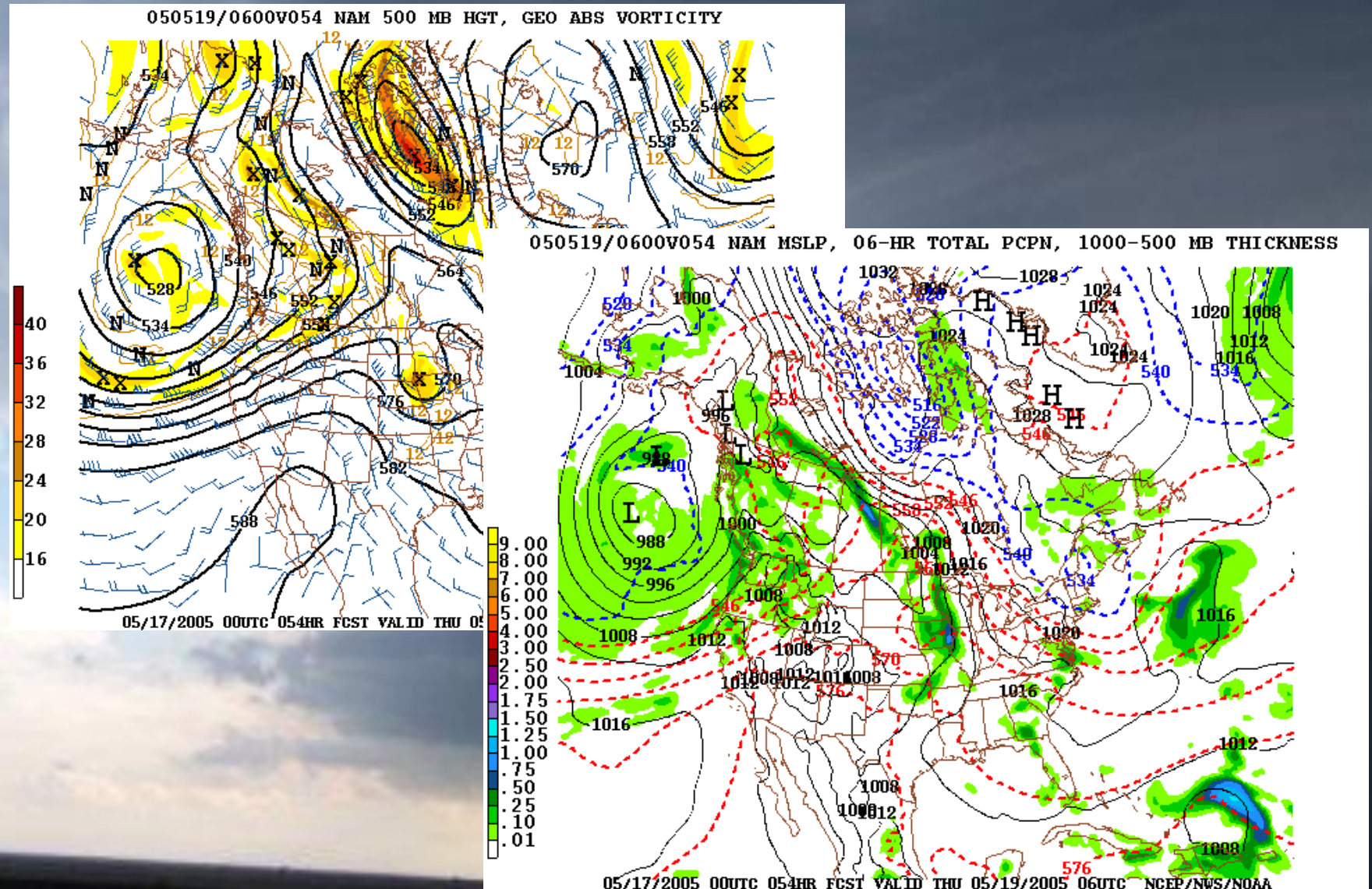
- Releases twice a day all over the world at the same time – 900 stations worldwide
- Measures temperature, humidity, pressure as it goes up
- Flight lasts about 2 hrs and can reach as high as 115,000 ft
- Bursts when it reaches it's elastic limit
- Data is input into computer models



# Computer Models

- Complex computer programs
- Atmosphere broken down into mathematical equations
- Computer solves equations at future points in time
- Helpful for determining environment in which storms will form

# Computer Model Output

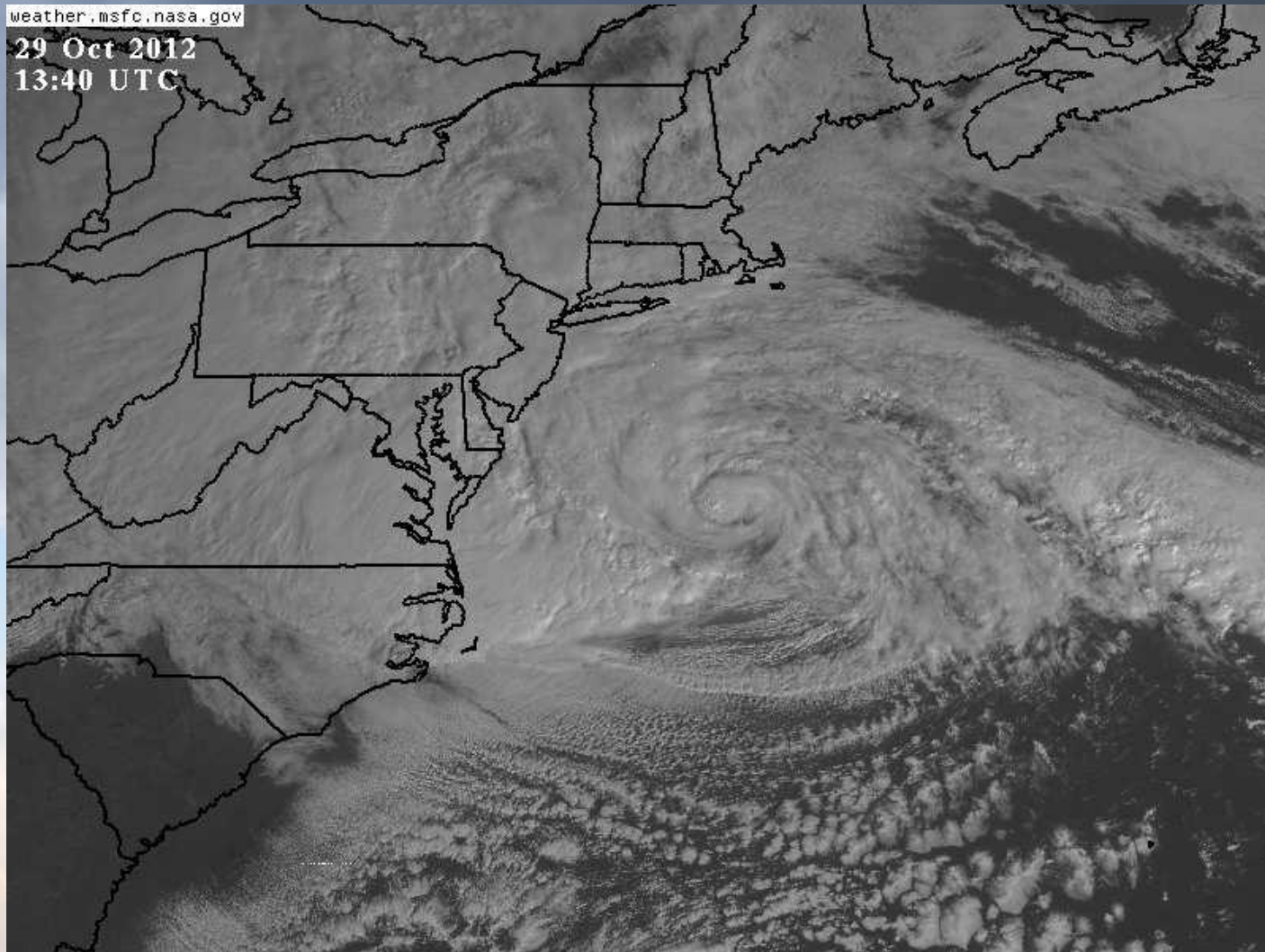


# Weather Satellites

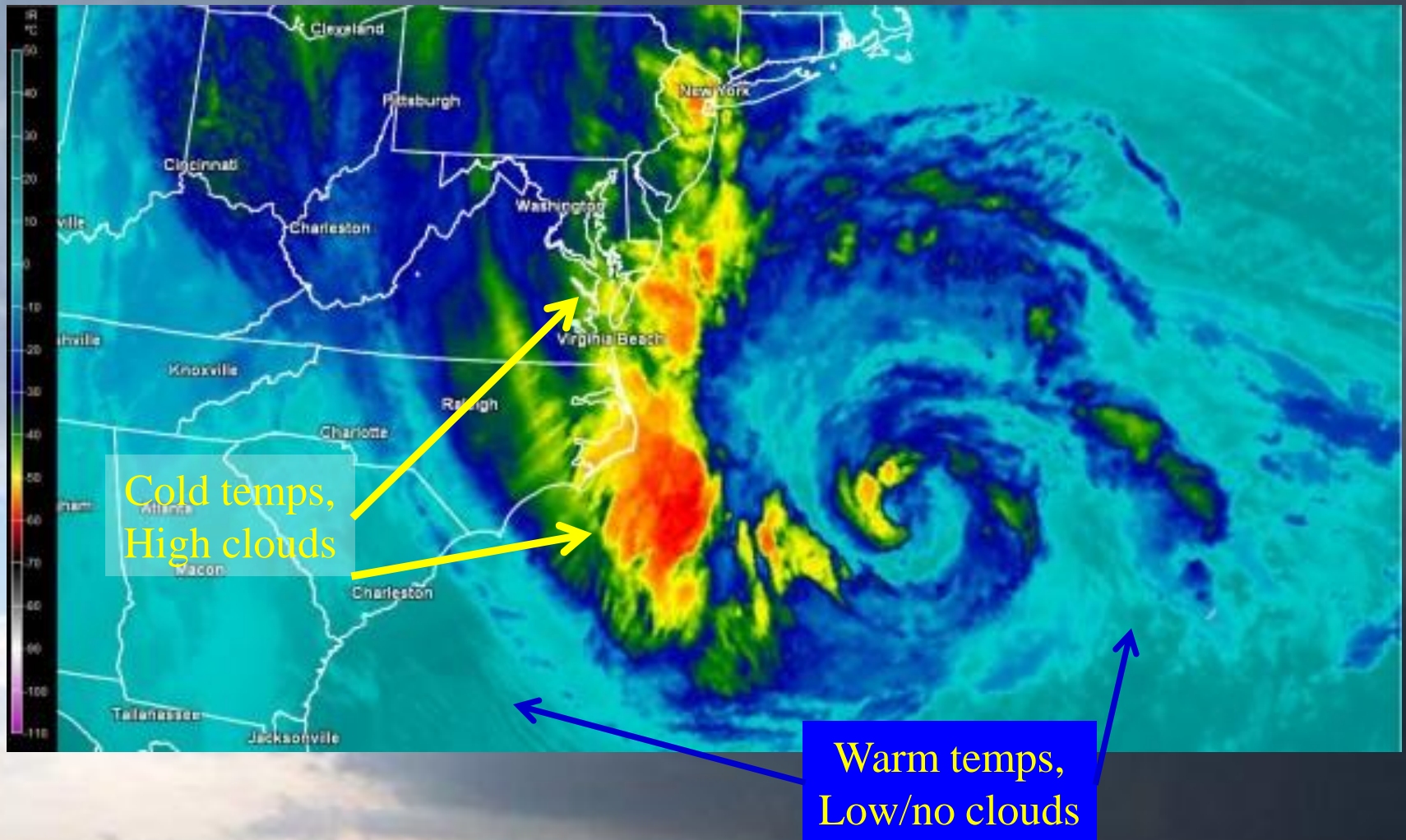
- Orbit 22,000 miles above the earth
- Stay over the same point on the earth (geostationary)
- Photographs the same areas every 5 to 30 minutes
- Pictures can be made into movies
- Visible and infrared images available



# Visible Satellite



# Infrared Satellite





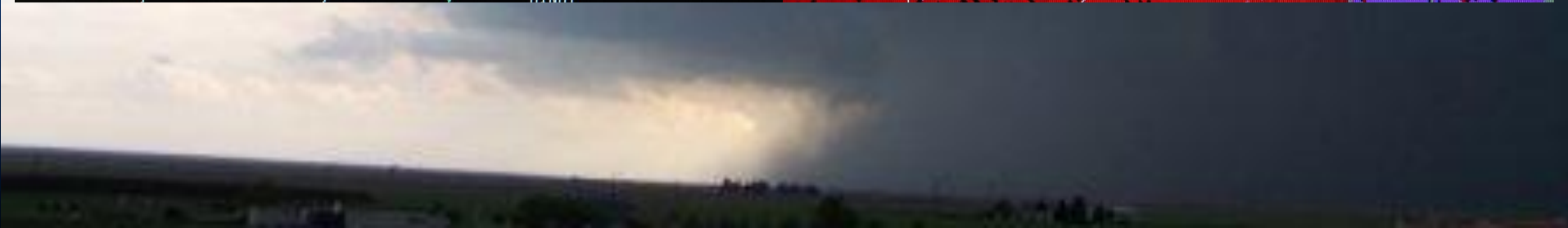
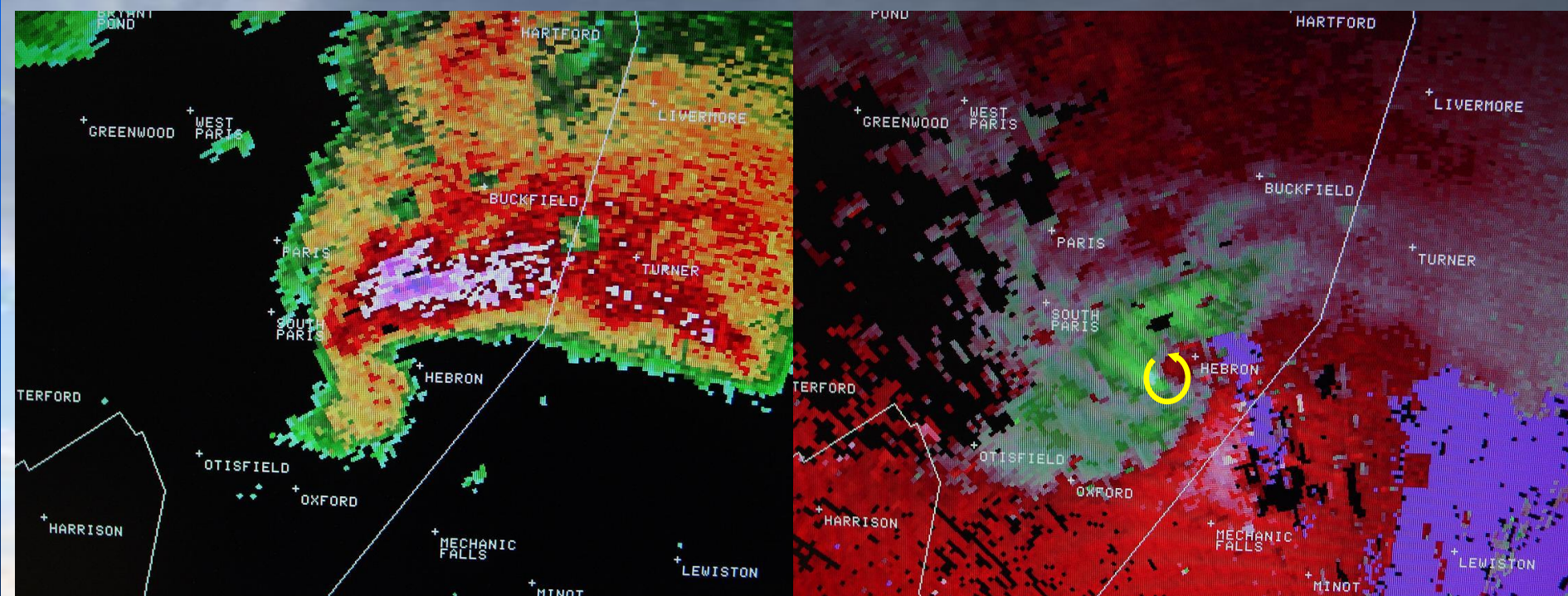
# Weather Radar Overview



- Transmitter sends out short burst of radio waves
- When waves strike an object, a very small portion of the energy is returned
- Process repeats about 1,000 times a second



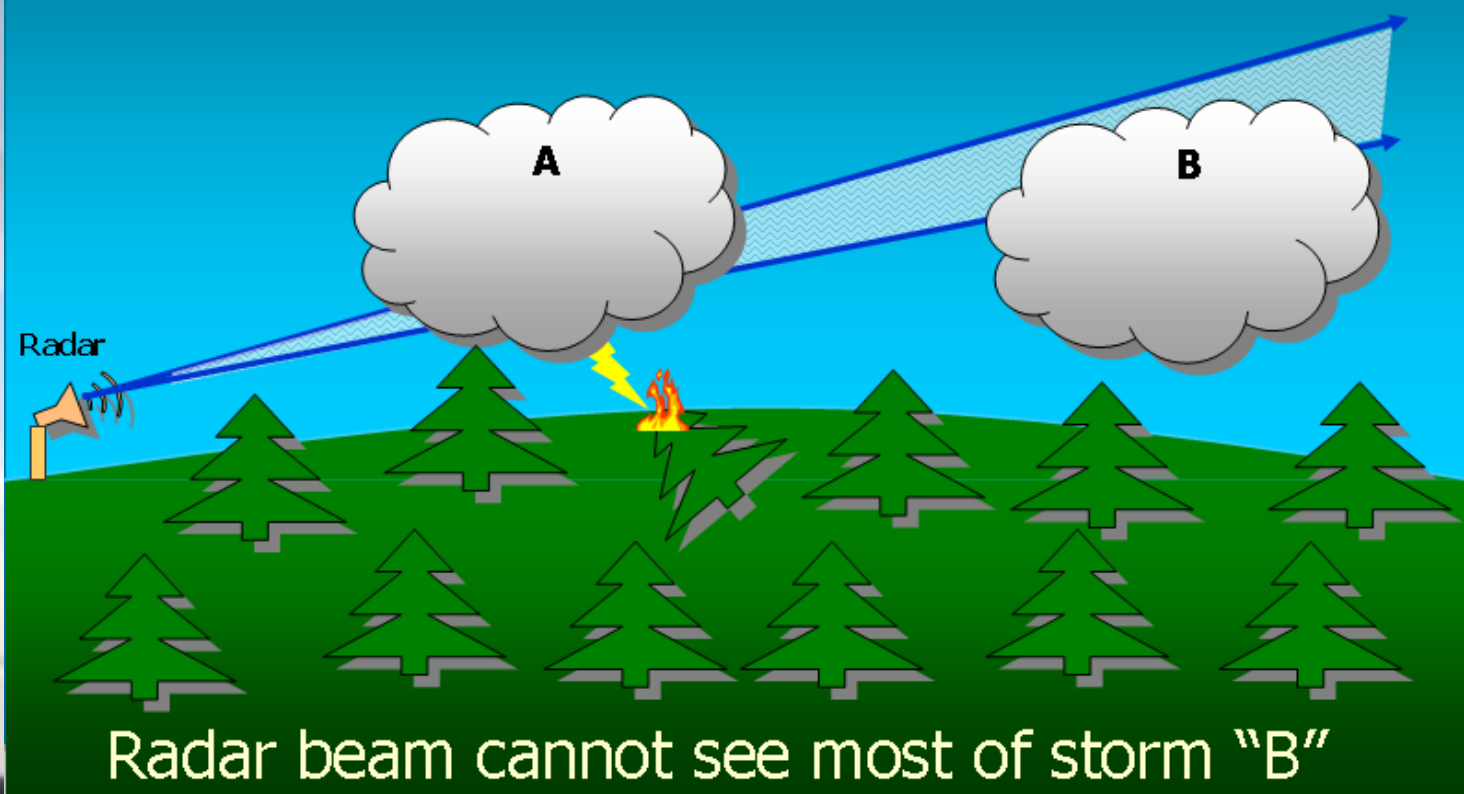
# WSR-88D Reflectivity + Velocity



# Radar Limitations

## Why we need spotters

Radar Horizon



# Storm Spotters

- Radar only provides data where scatterers (rain drops or hailstones) are present
- Cloud formations can also provide insight into a storm's intensity
- Trained volunteer spotters provide visual observations to go with the radar and satellite data



# The Spotter's Role

Ground Truth - What's really happening:



Phippsburg, ME

# The Spotter's Role

To be the eyes of the NWS where severe weather is occurring or has occurred:

- Reporting storm type or structure
- Reporting damage, flooding or injury from storms

**This is Ground Truth**

# Thunderstorms in New England

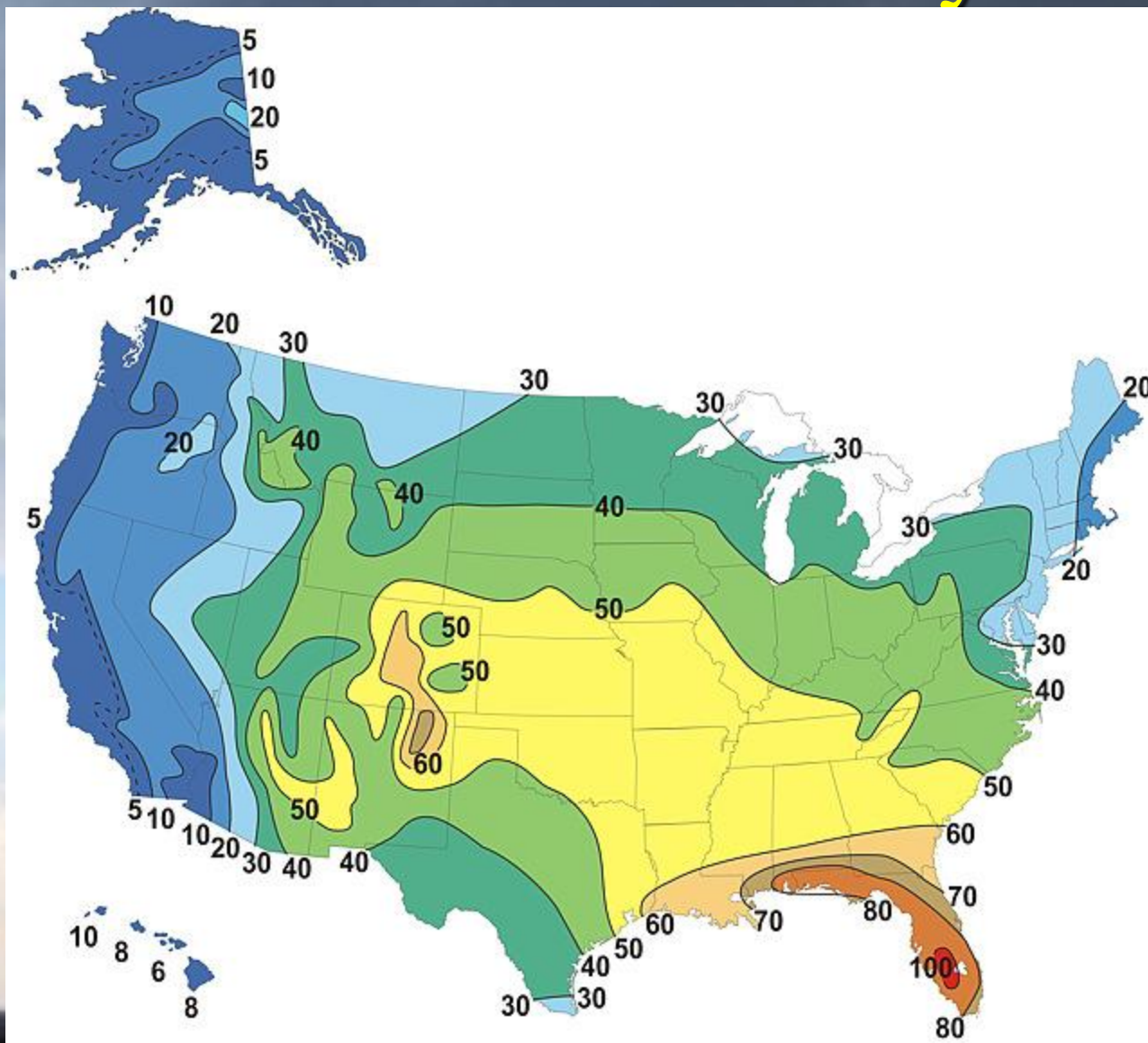
Copyright S. Hanes



- Most severe weather occurs from May through early July
- Most severe weather occurs during the afternoon and evening
- BUT...severe weather can occur any time!

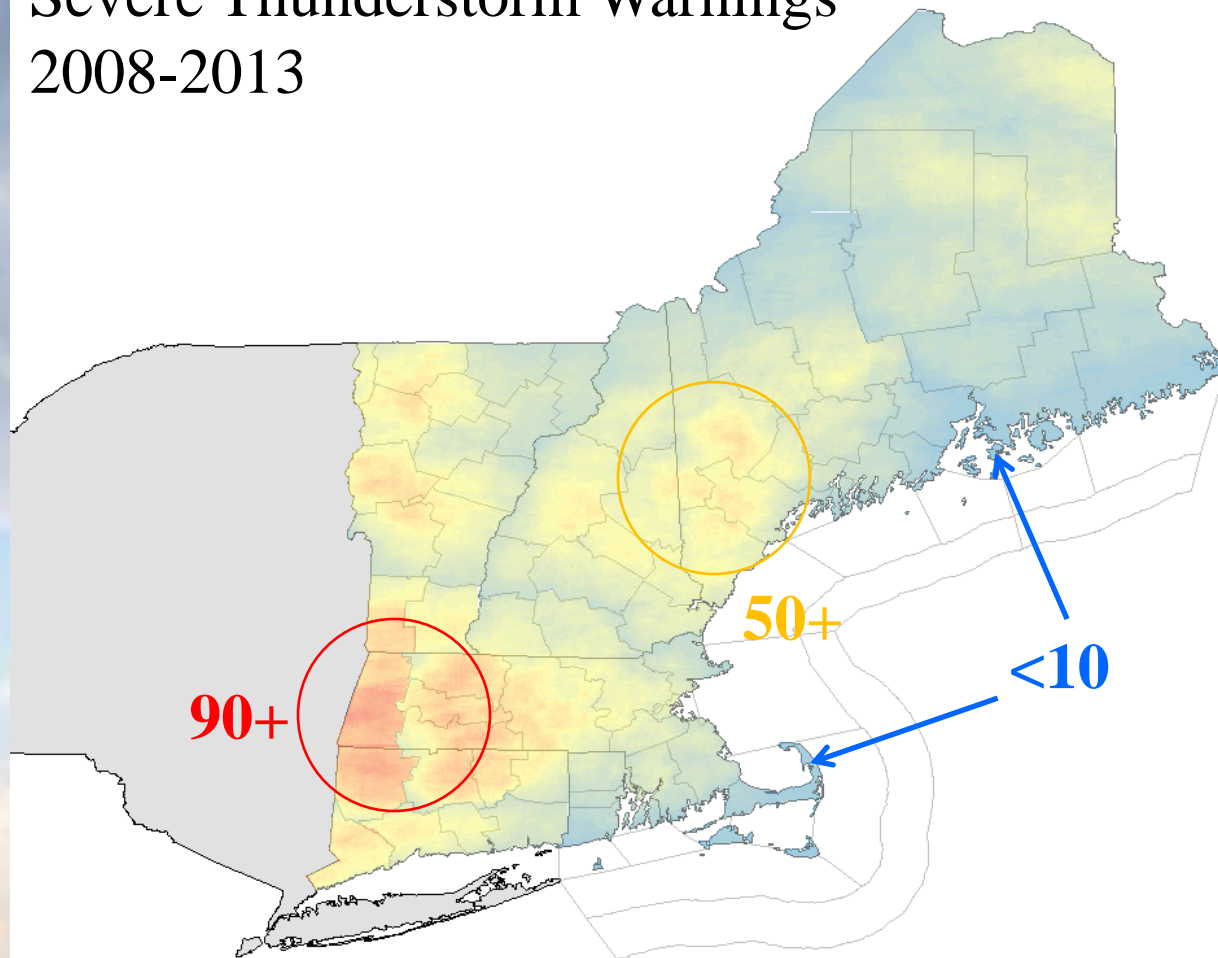


# Thunderstorm Days



# Severe Thunderstorms

Severe Thunderstorm Warnings  
2008-2013



# Thunderstorm Threats

- Tornadoes
- “Straight-line” winds
- Flash Flooding
- Hail
- Lightning





# Conditions for Thunderstorms

All thunderstorms, severe or not, need three ingredients in order to form:

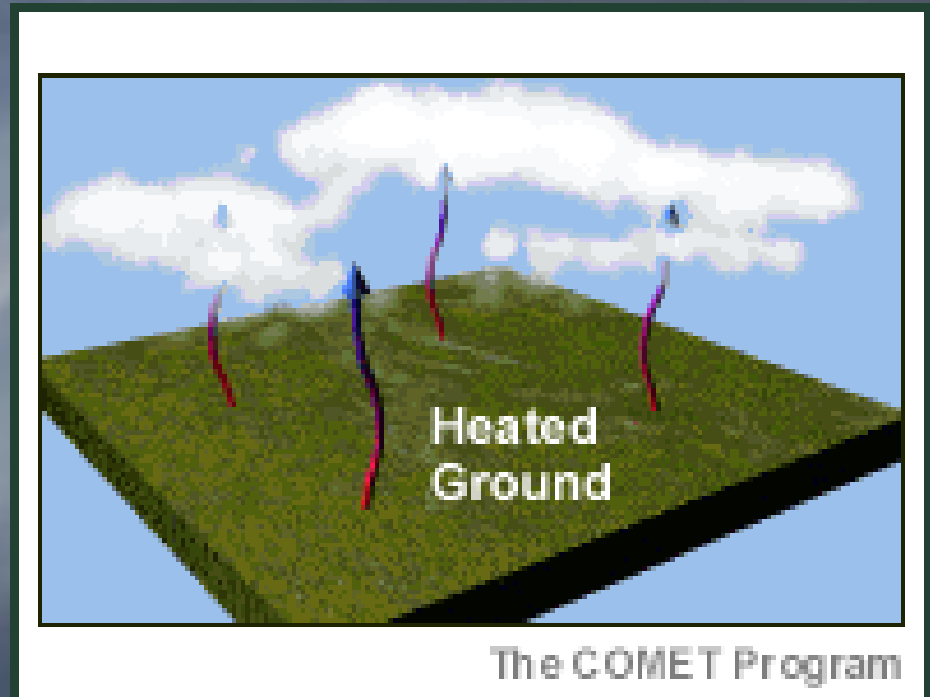


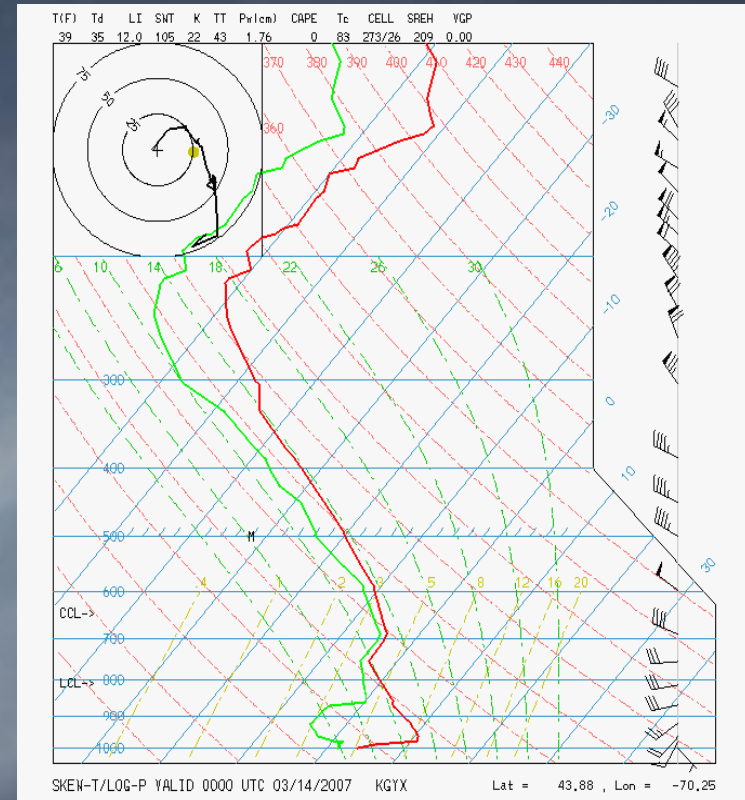
1.) Moisture 2.) Instability 3.) Lift

# Instability (Non-mechanical Lift)

## Convection:

The sun heats the earth's surface, parcels of air rise like bubbles. They continue to rise as long as they remain warmer than the air around them.



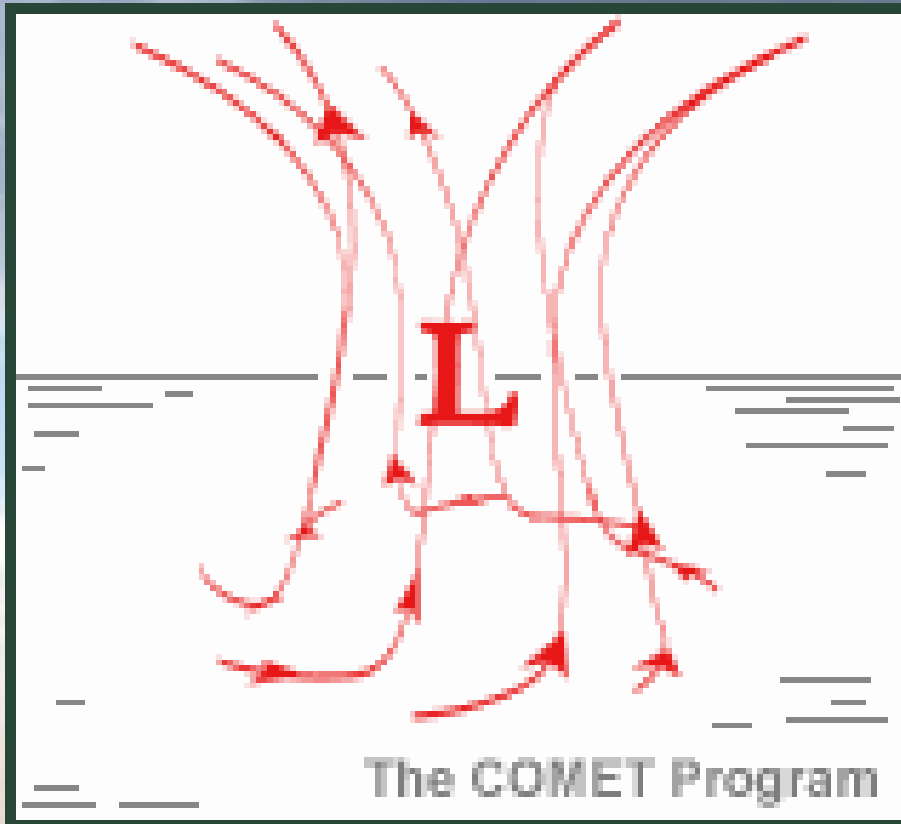


Weather balloons provide a vertical profile of the air, which help us “see” instability.



# Thunderstorms

## *Mechanical Lift*



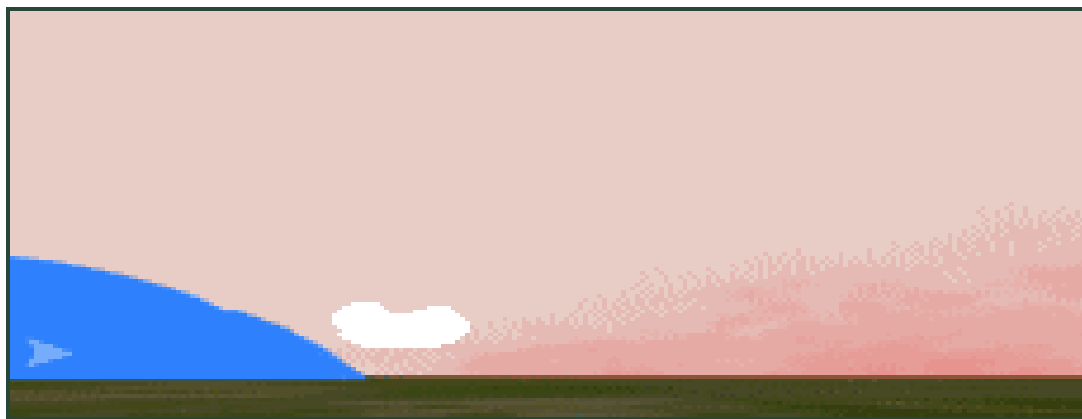
**Convergence:**  
where winds from  
different directions  
meet, or fast winds  
meet slow winds.

# *Mechanical Lift*

## Fronts:

boundary  
between two air  
masses  
with different  
characteristics.

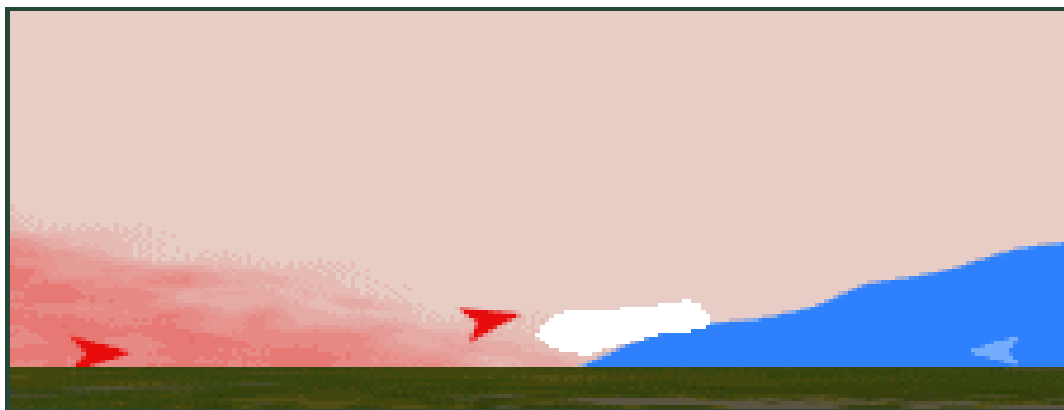
Cooler (drier) air  
is more dense –  
acts as a wedge.



Cold Front

- Cold Air
- Warm Air
- Warmer Air

The COMET Program



Warm Front

- Cold Air
- Warm Air
- Warmer Air

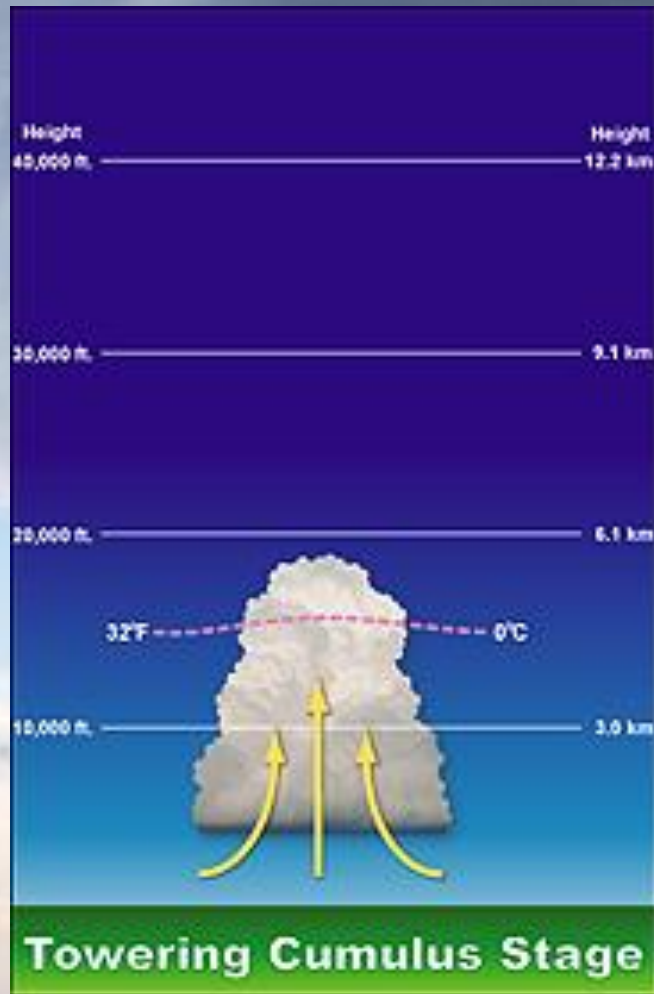
The COMET Program

# Pulse Storms

- Pulse storms are thunderstorms, which can be briefly severe.
  - Their core aloft ‘collapses’ resulting in a downburst of high winds
  - Warning lead time may be short, but some lead time can be provided.
  - No mesocyclone
  - Often short-lived

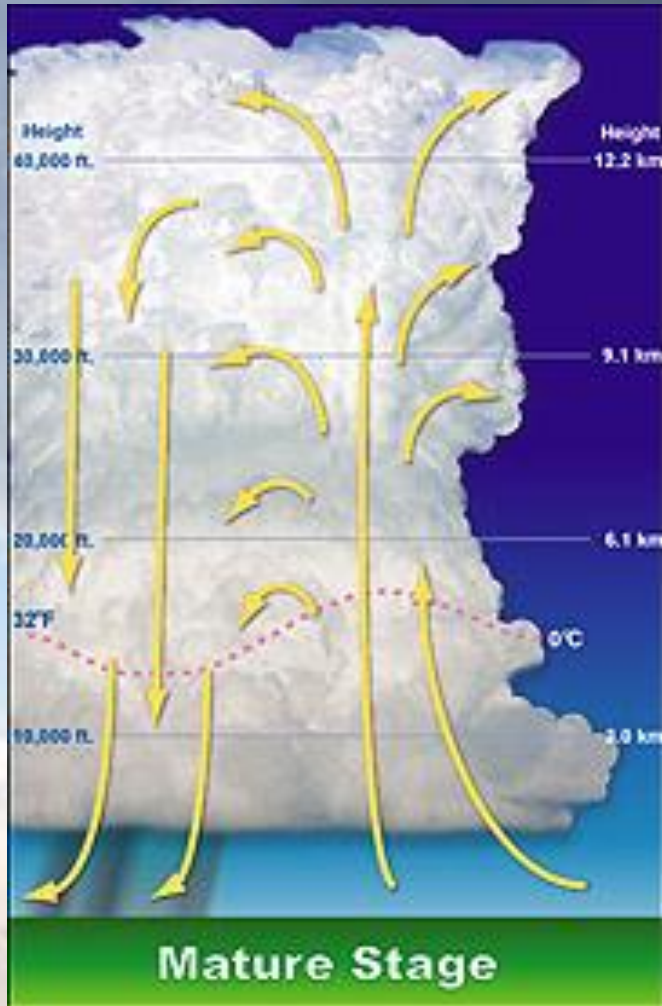


# Thunderstorm Life Cycle



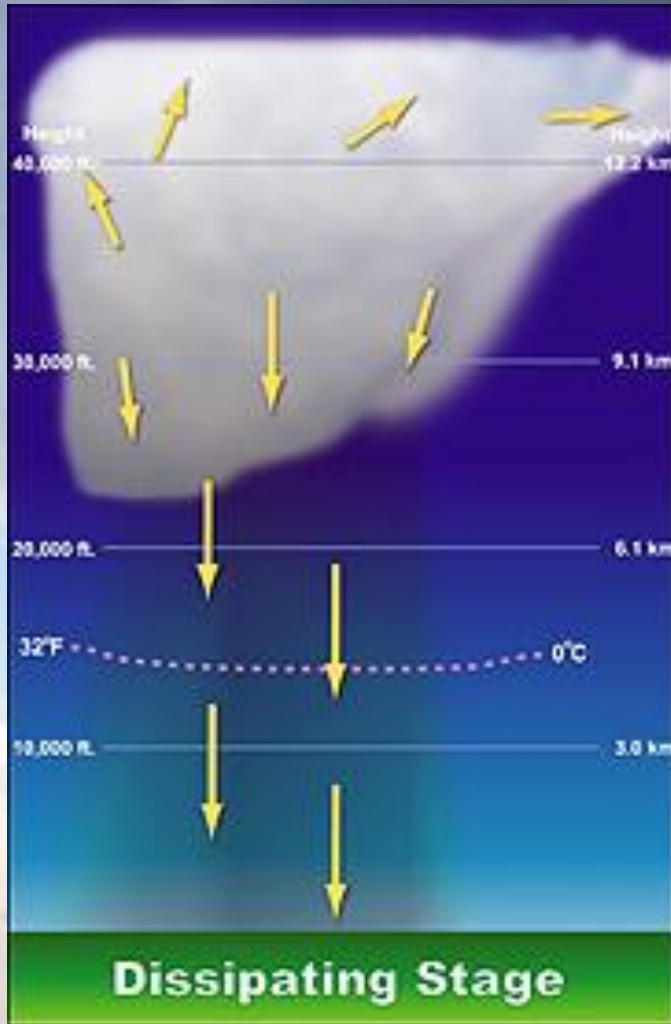
- Towering cumulus stage
- Nearly all motion is upward (updraft)
- Little or no rain

# Thunderstorm Life Cycle



- Mature stage
- Water in cloud is heavy enough to fall as precipitation
- Updraft, downdraft, and precipitation all occurring
- Most likely time for severe weather

# Thunderstorm Life Cycle



- Dissipation stage
- Precipitation and downdrafts cut off the updraft
- Nearly all motion is downward
- Storm weakens but can still contain high winds

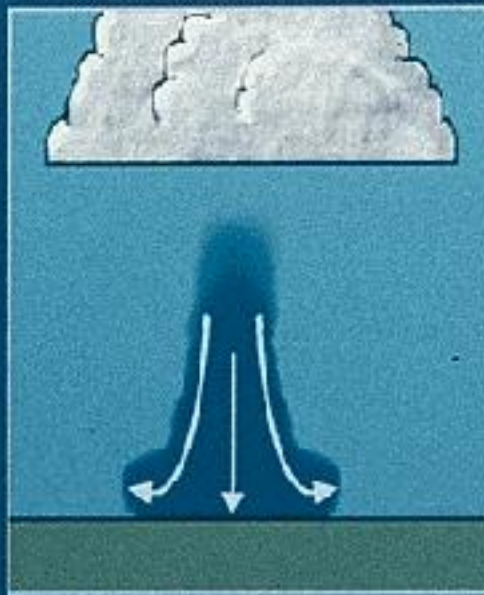


# Downbursts

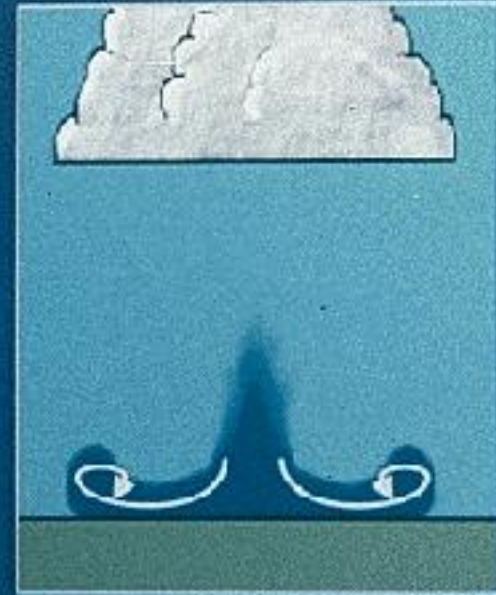
## Downburst Life Cycle



**FORMATION -**  
Evaporation and  
precip. drag  
forms downdraft



**IMPACT -**  
Downdraft quickly  
accelerates and  
strikes ground



**DISSIPATION -**  
Downburst moves  
away from point  
of impact

# Thunderstorm Winds or Downbursts

Much more common than  
tornadoes

Especially dangerous to  
mobile homes, vehicles,  
and aircraft



Winds can exceed 100 mph

Damage swath can cover  
several hundred miles





# Shelf Cloud



New Gloucester, ME

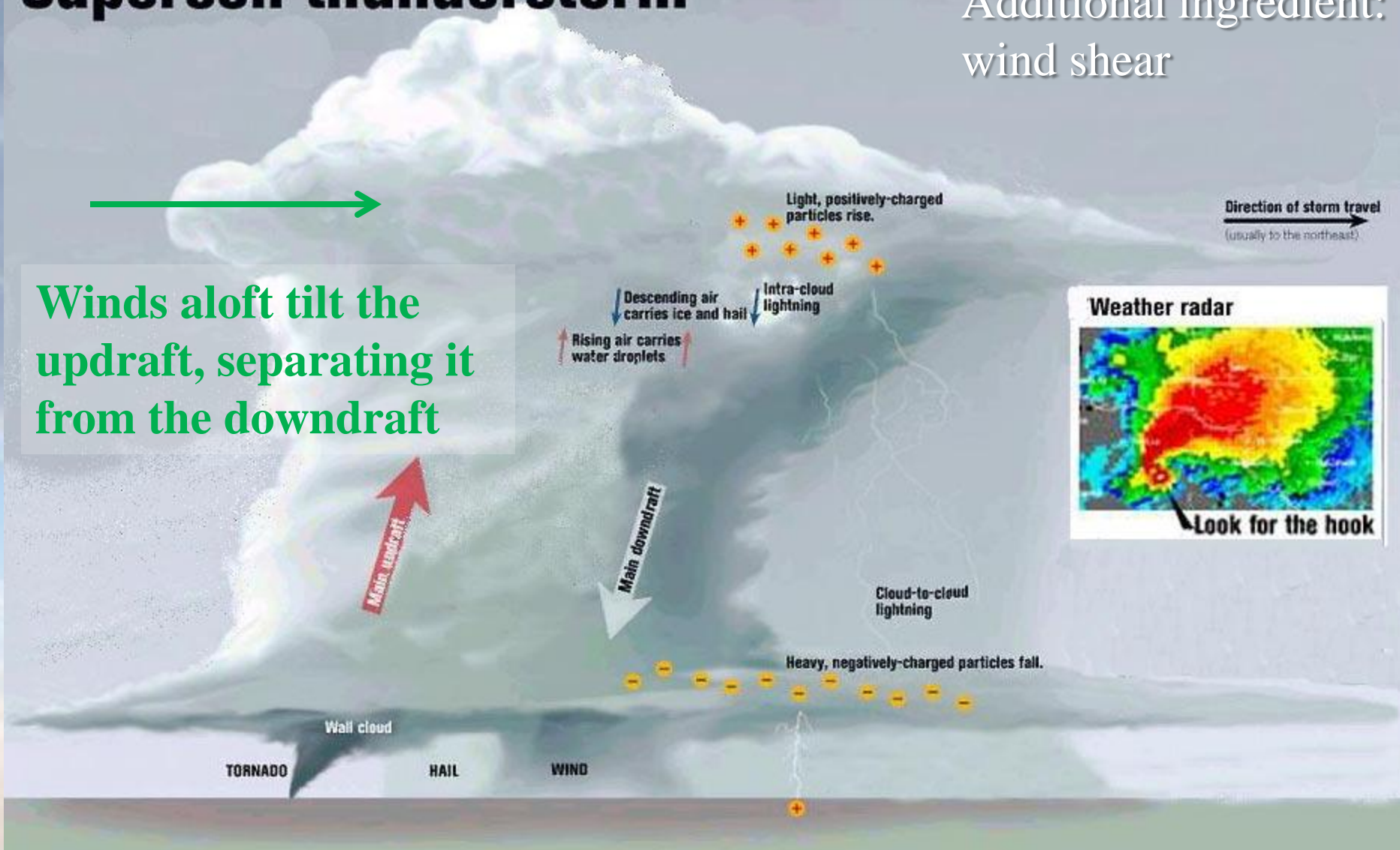




# Supercell thunderstorm

Additional ingredient:  
wind shear

Winds aloft tilt the  
updraft, separating it  
from the downdraft





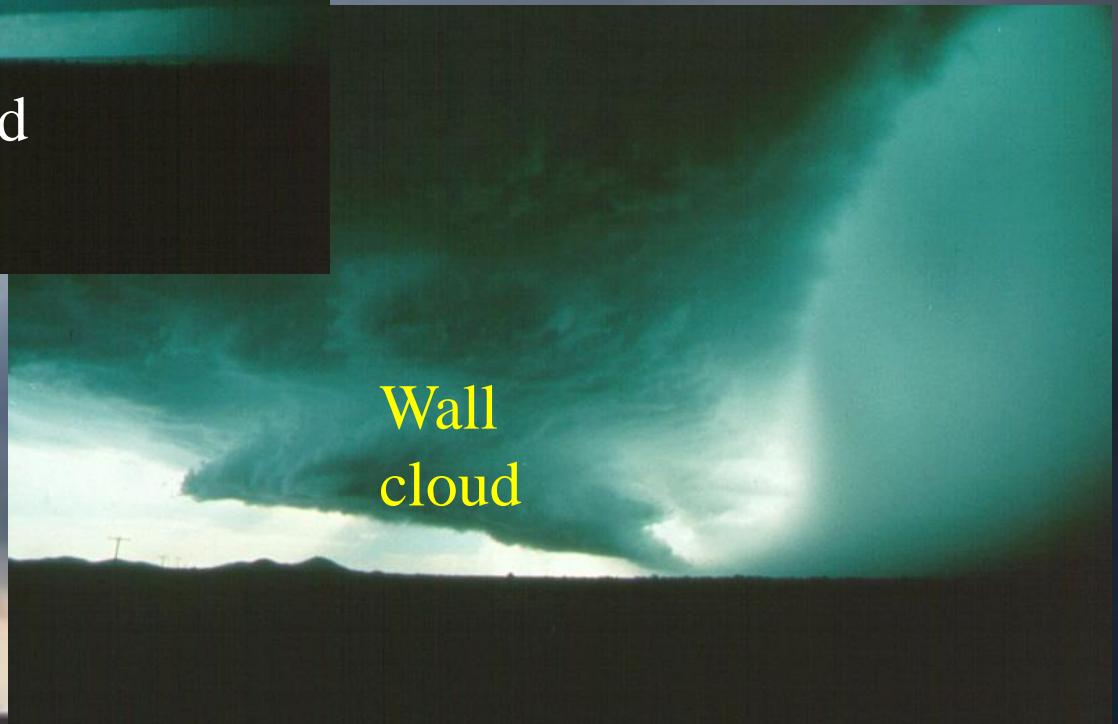




# Supercell Thunderstorm Features

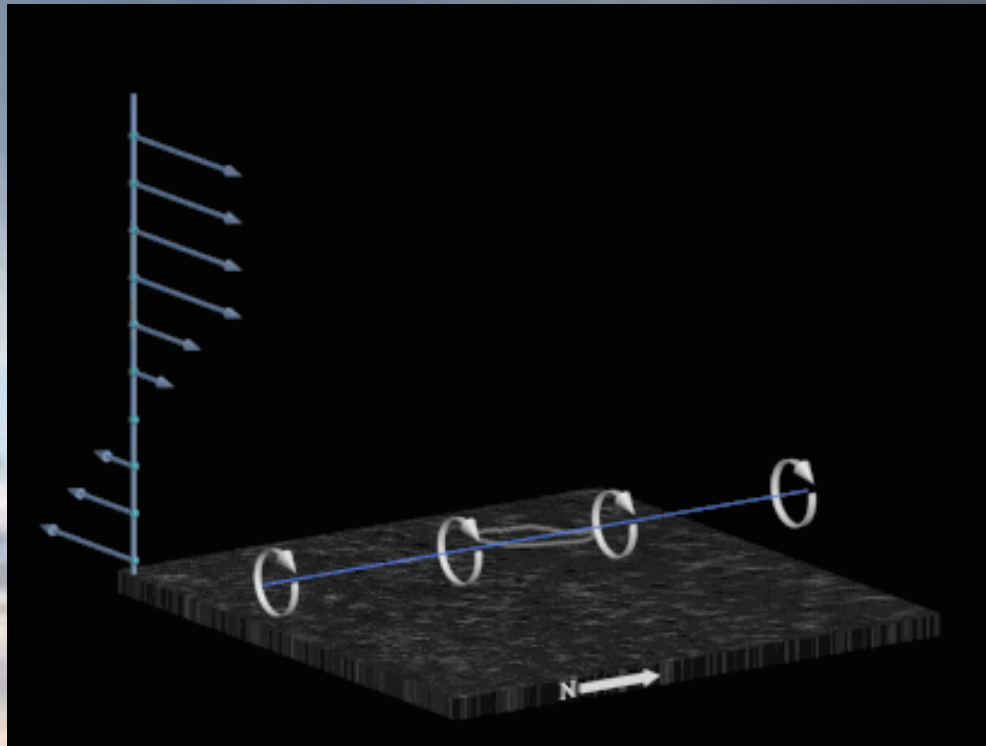
- Mesocyclone – tilted, rotating updraft allows downdraft and updraft to exist separately
- Wall Cloud – lowering of cloud base beneath updraft
- Funnel/Tornado – occurs within updraft
- Hail – Large ice chunks falling from thunderstorm

# Supercell Thunderstorms



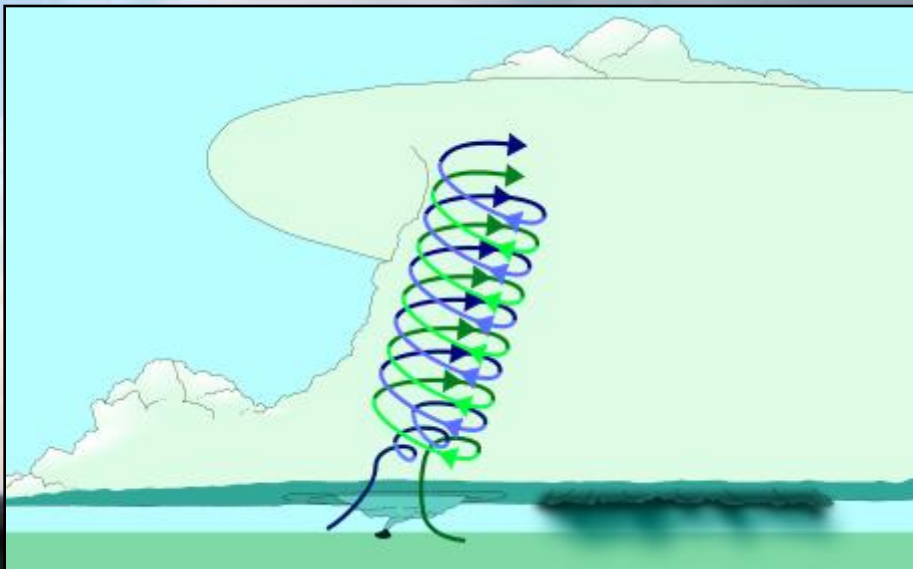
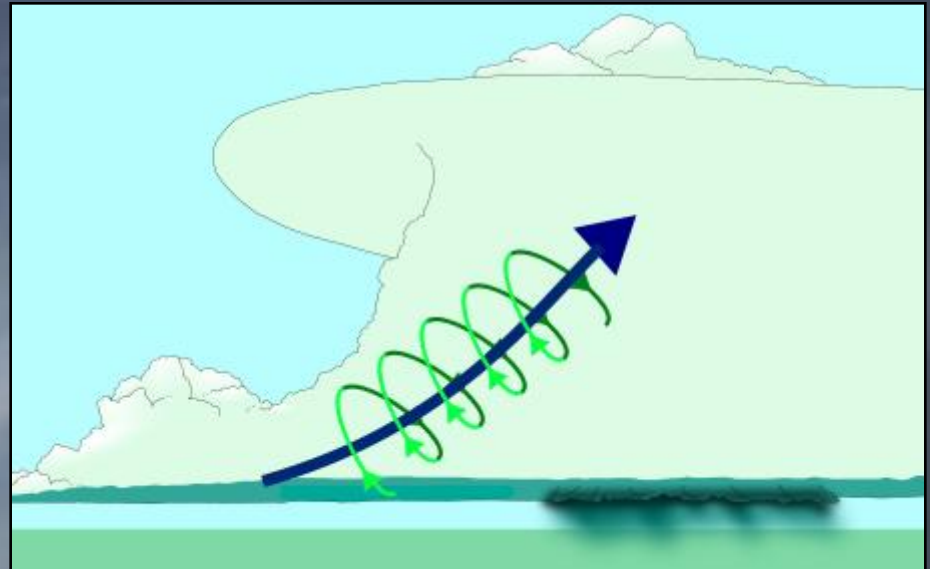
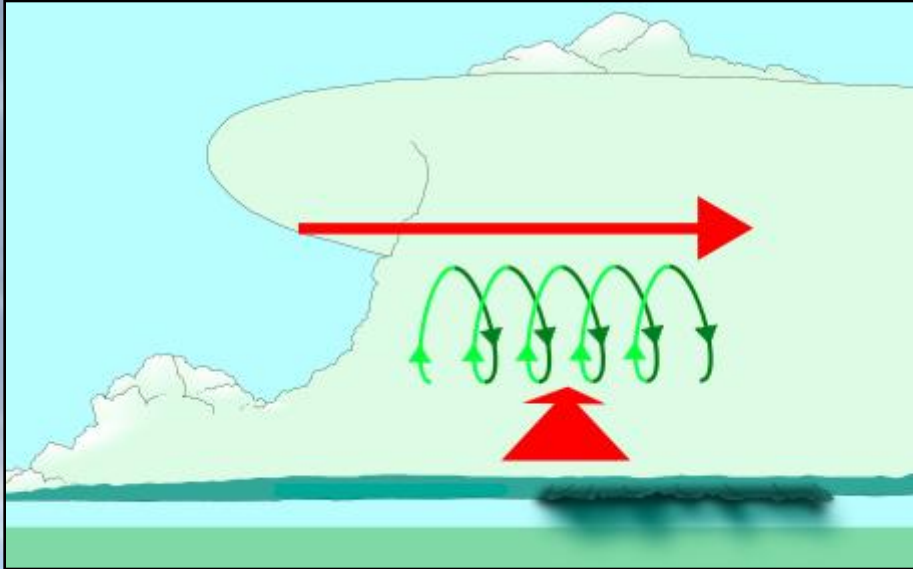
# Mesocyclone

Rotation of updraft at or below cloud base



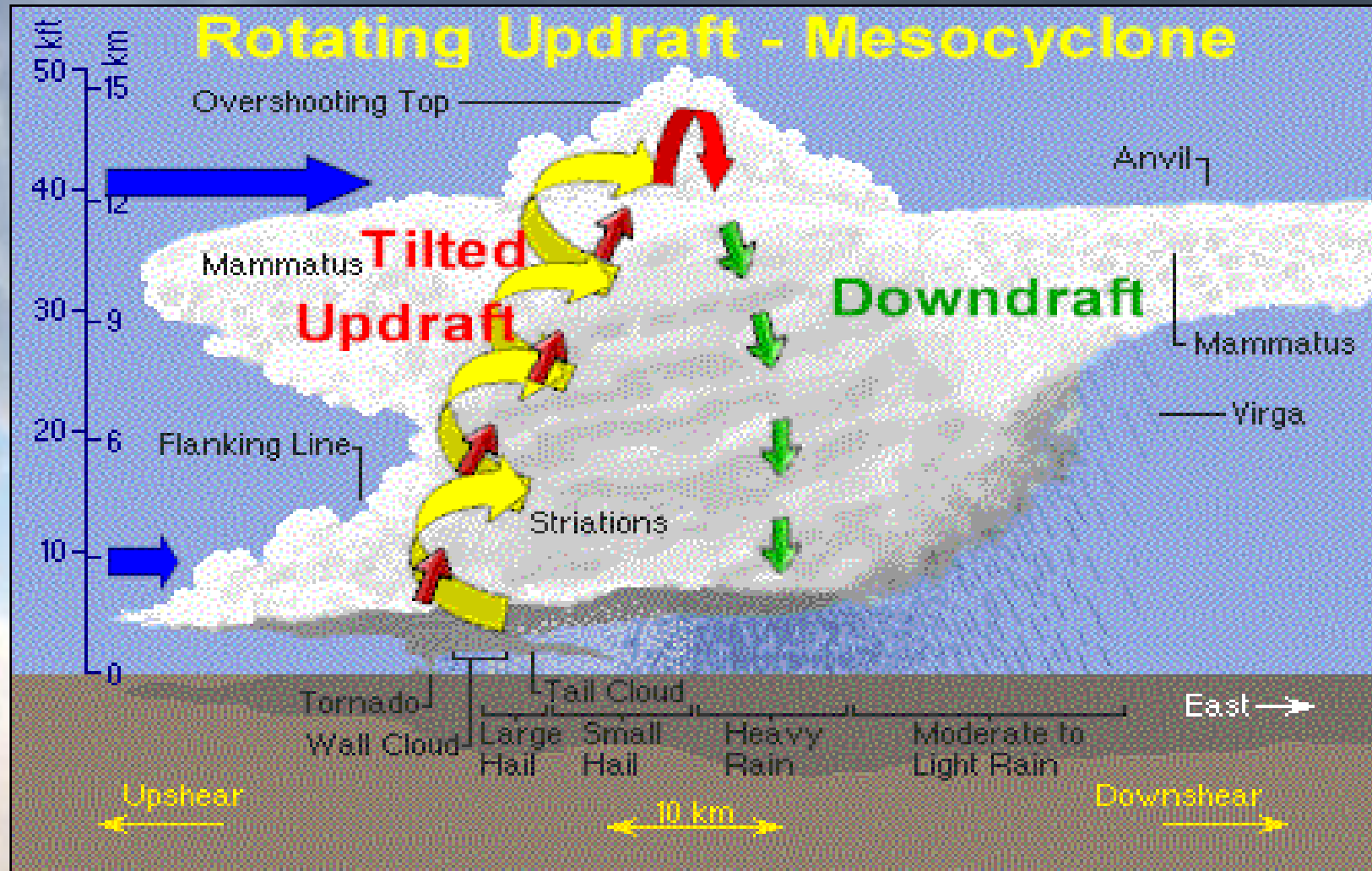


# Mesocyclone Formation



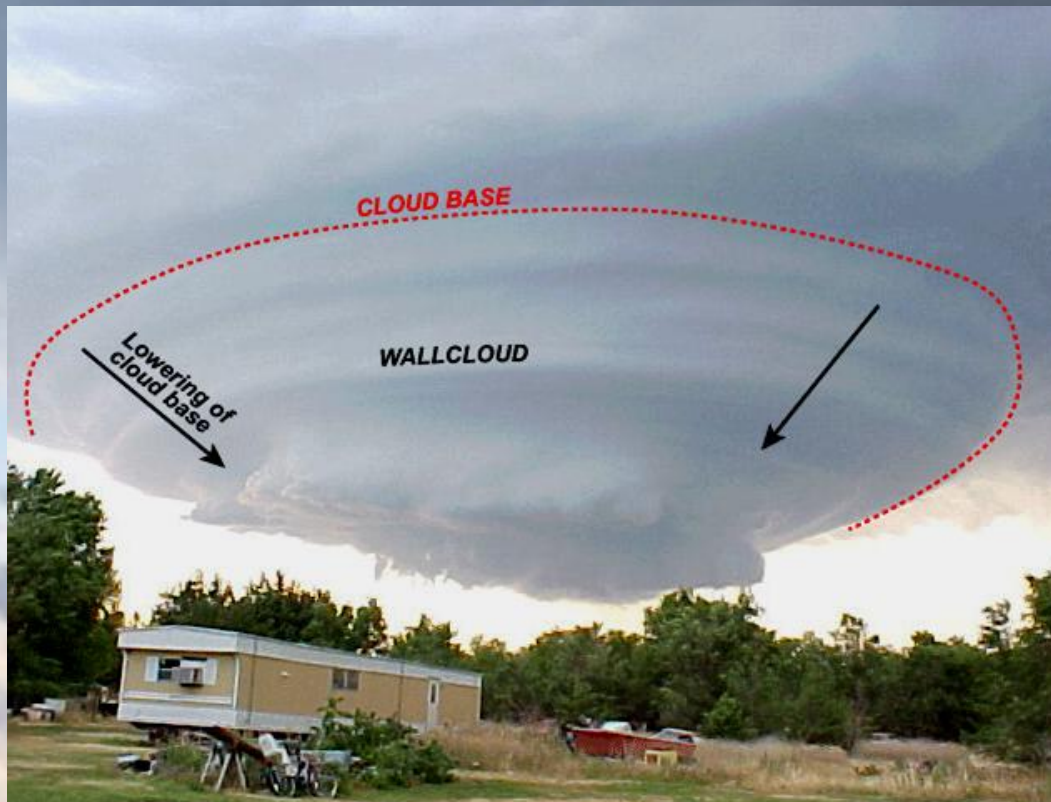
Formed by tilting  
horizontal rotation  
generated by shear  
into the vertical

# Mesocyclone



# Wall Cloud

Lowering of the cloud base – enhanced  
condensation and inflow







May or may not rotate -  
rotation is precursor to  
tornado development

Tilts downward  
toward the rain



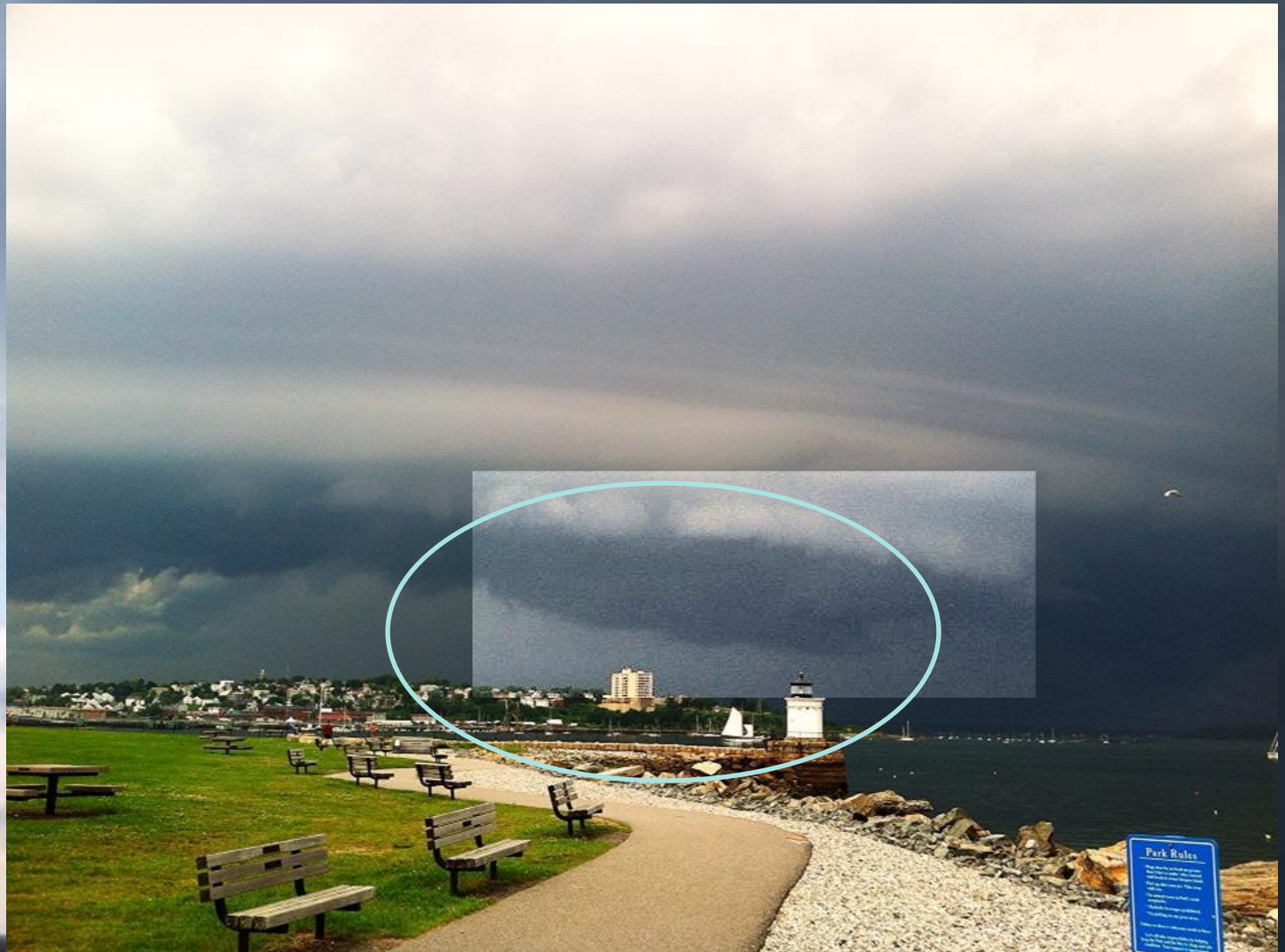
# Wall Cloud in NH



# Wall Cloud in Portland

Photo by  
Chris Legro

Portland, ME  
June 24, 2013





# Scud



Tom Warner

# Funnel Cloud

Rotating funnel-shaped cloud extending downward from a thunderstorm base, but not necessarily in contact with the ground.



Funnel cloud

National Weather Service Forecast Office, San Antonio, TX NOAA Central Library



# Tornado

Violently rotating column of air, attached to a thunderstorm base, and in contact with the ground



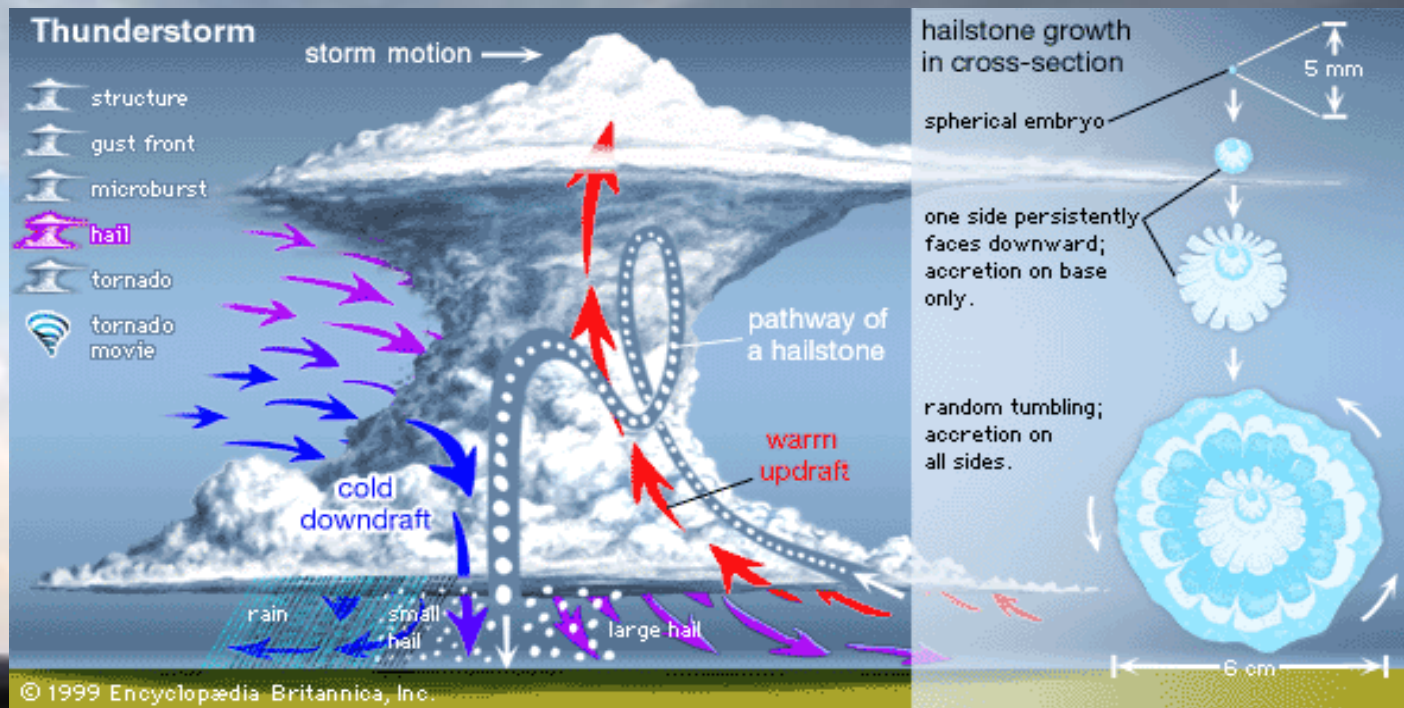




Look for the  
dust/debris to  
determine  
contact with  
ground

# Hail Formation

- Updraft continues moving water droplets above freezing level
- Droplets freeze to nuclei, hailstones grow
- Hailstones fall when they move out of updraft or become too heavy



# Large Hail



The most destructive weather element

Annually causes \$1 billion in damage

Can reach the size of softballs

Fall speeds up to 100 mph (potentially fatal)





- 0.25" - Pea
- 0.50" - Mothball (M&M)
- 0.75" - Penny/Dime
- 0.88" - Nickel
- 1.00" - Quarter
- 1.25" - Half Dollar
- 1.50" - Ping Pong
- 1.75" - Golf Ball
- 2.00" - Hen Egg
- 2.50" - Tennis Ball
- 2.75" - Baseball
- 4.50" - Softball



*Coins or Sports Balls  
(or candy?)*

# Tornadoes



- Strong/violent tornadoes are rare, but cause most damage
- Enhanced Fujita scale rates tornadoes based on damage

# Tornadoes - Weak



About 82% of tornadoes nationwide

Winds up to 110 mph

Lifetime about 1-10 min

Path length usually a couple miles or less

Low percentage of national casualties/damage

Fujita scale: EF0 and EF1



# Tornadoes - Strong



About 17% of tornadoes nationwide

Winds 110 to 205 mph

Lifetime about 10-20 min

Path length usually 5-15 miles

Medium percentage of national casualties/damage

Fujita scale: EF2 and EF3

# Tornadoes - Violent



Only about 1% of  
tornadoes nationwide

Winds  $> 205$  mph

Lifetime up to an hour

Path length up to 50  
miles

Large percentage of  
national  
casualties/damage

Fujita scale: EF4 and EF5





# New Hampshire TORNADO

## July 24, 2008

About 50 mile path length.

Max width ½ mile

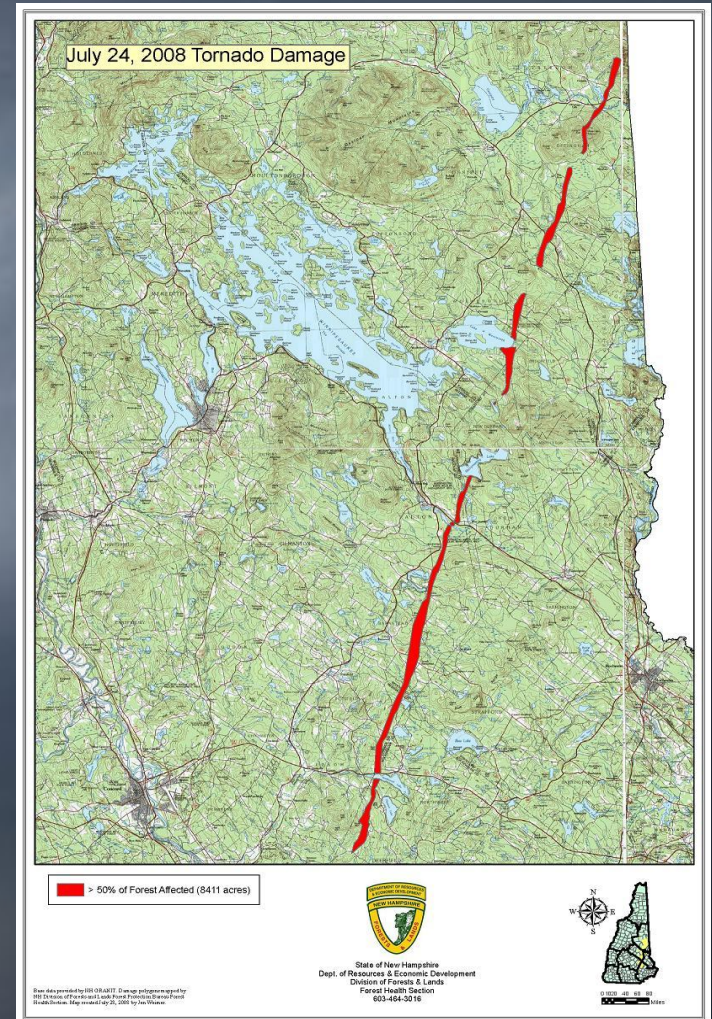
Moved through 5 counties

Tornado wrapped in rain. No eyewitness reports of funnel.

One fatality

Rated EF2

Areas in red on map had 50% or greater tree damage



# New Hampshire TORNADO

## July 24, 2008





# Hampton Falls TORNADO

## May 21, 2006





# Tornado Safety at Home or Work



- Somewhere underground is best
- If no underground shelter, get to a small, interior room on the lowest floor
- Closets and bathrooms are good
- Cover yourself with blankets or a mattress

# Tornado Safety in Vehicles



- Abandon vehicles for a substantial building
- Cars can be easily tossed about by a tornado's winds
- As a last resort, take cover in a culvert or ditch, but this is not as safe as a solid building



# Leighton, AL TORNADO





# Tornadoes vs. Downbursts

## Tornadoes

- Occurs in thunderstorm updraft
- Air is pulled INTO the tornado and up into the thunderstorm.
- Debris is lifted into the tornado and tossed out

## Downburst

- Occurs in thunderstorm downdraft
- Air is thrust OUT from the thunderstorm toward the ground and then spreads outward along the ground.
- Debris is blown along the ground but rarely lifted.

# Flash Flooding



The #1 killer among severe weather events

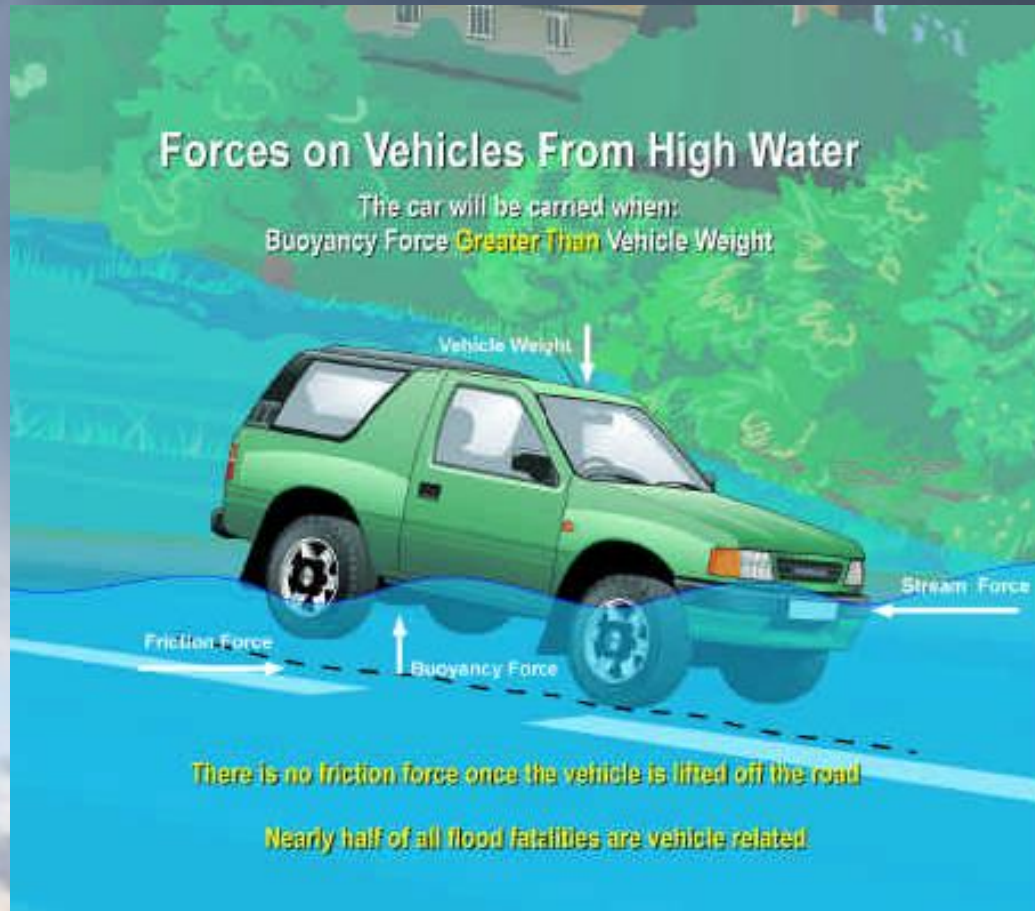
Approximately 100 deaths annually

Most deaths occur in vehicles

Many deaths occur at night

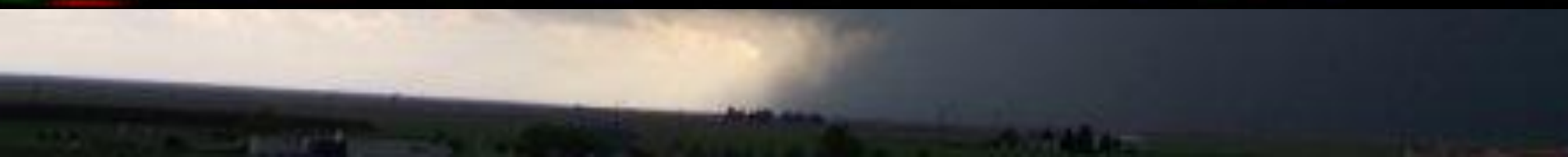


# Flash Flood Dangers



- 2-3 feet of water can float most vehicles
- 6-12 inches can knock a person off balance





# Flash Flood Safety



- Turn Around, Don't Drown<sup>tm</sup>
- Stay clear of flooded areas!
- Stay away from creeks or ditches
- If camping or hiking, know where the high ground is
- Be especially cautious at night



October 1996



Westbrook, ME



Old Orchard Beach, ME



Scarborough, ME



# Lightning

The #2 killer among weather events

Boaters, golfers, people in open are most vulnerable



Temperature is about 50,000 degrees F

Electric current about 30,000 amperes

# Lightning Safety



- Move inside a strong, grounded building
- Move away from water and open areas
- Turn off electrical appliances
- Move inside at the first thunder
- Stay in shelter until 30 minutes after last thunder





# Severe Thunderstorm Safety

- Move inside a strong building
- Stay away from windows
- Mobile homes and vehicles offer poor protection from wind
- Vehicles offer fair protection from hail smaller than golf balls

# What to report?

Tornado	Flash Flooding
Funnel Cloud	Rain >1 inch / hour
Rotating Wall Cloud	Rain > 2 inches in a few hours
Winds 50 mph + Any Wind damage	Snow > 1 inch / hour Storm Total Snow
Hail (any size)	Precipitation Type

# What to report

- Tornadoes, funnel clouds, wall clouds
- Hail, high winds, flash flooding
- Any damage caused by storms, including lightning damage
- We commonly verify Severe Thunderstorm Warnings with downed trees – how many, how large in diameter, and where.



# What *not* to report:

- Lightning- we have an accurate detection system
- “Dark sky,” “It’s starting to rain,” “It’s raining hard,” etc.

# How to report

■ Call:

800-482-0913

■ E-mail:



*gyx.skywarn@noaa.gov*

■ Web site: *www.weather.gov/gray*

*“Send a storm report”*

# NWS Gray Website

*www.weather.gov/gray*

**NATIONAL WEATHER SERVICE**  
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

HOMEFORECASTPAST WEATHERWEATHER SAFETYINFORMATION CENTERNEWSSEARCHABOUT

Local forecast by  
"City, St" or ZIP code

Enter location ...

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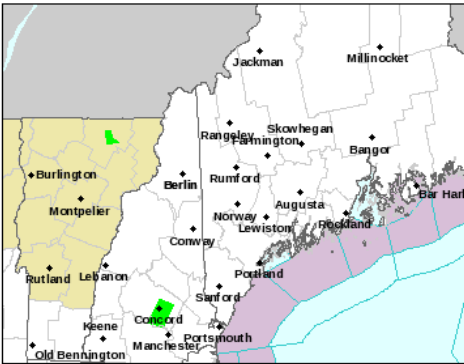
**NWS Forecast Office Gray/Portland, ME**

[Weather.gov](#) > Gray - Portland, ME

Gray - Portland, ME  
Weather Forecast Office

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Click on the map below to zoom in.



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Warnings &  
Advisories](#)


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Zoom  
Out


Last Map Update: Wed, Apr. 9, 2014 at 11:11:16 pm EDT




Radar




Current Weather




Rivers & Lakes



Satellite



Weather Information  
Display



Forecast Maps



# Thunderstorm Review

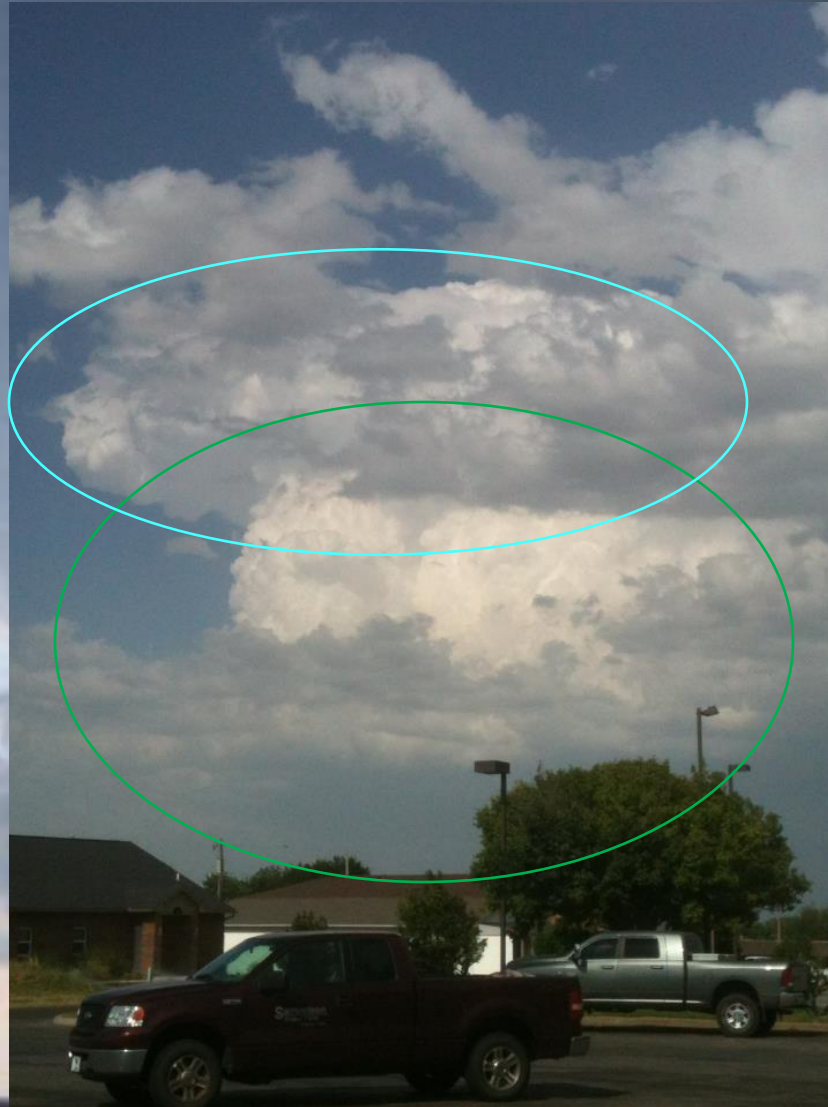


Towering  
Cumulus

Puffy nature of  
clouds indicates  
rising motion

Woodward, OK  
May 19, 2012

# Thunderstorm Review



Mature  
Thunderstorm

Clouds spread out  
at a stable layer  
(tropopause)

Large sustained  
updraft

Woodward, OK  
May 19, 2012

# Thunderstorm Review



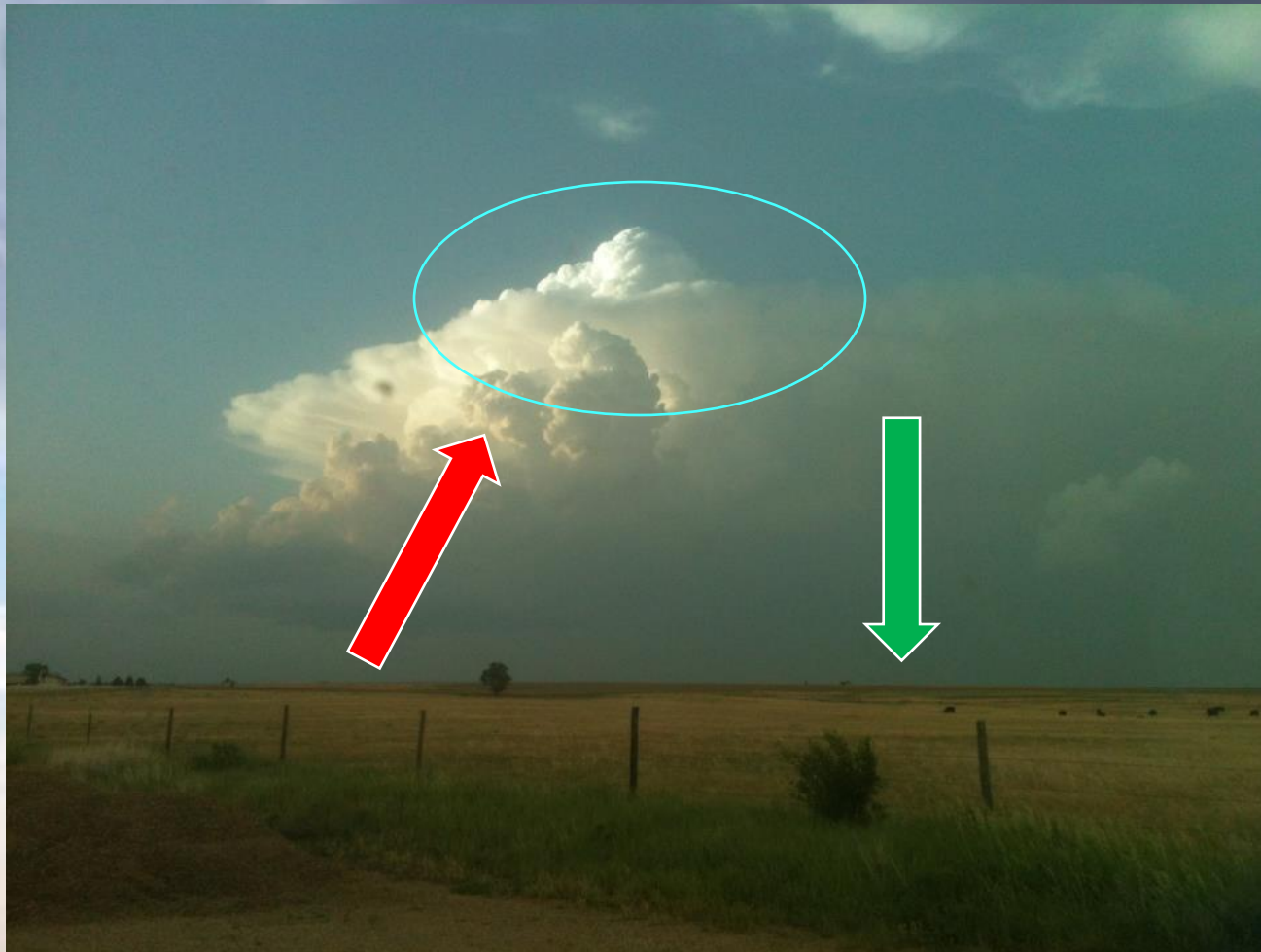
Supercell  
Thunderstorm

Well developed  
“anvil” structure

Hays, KS  
May 27, 2012



# Thunderstorm Review



Overshooting top

Updraft is strong enough to penetrate the stable tropopause

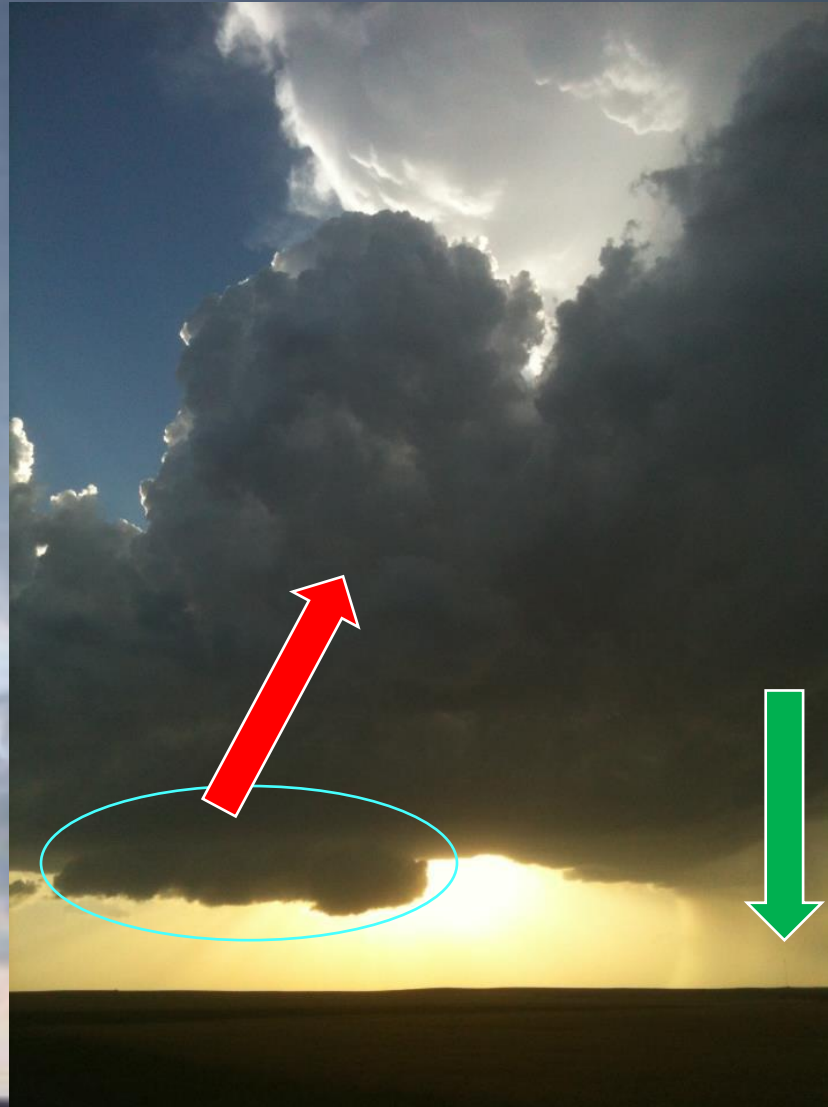
Tilted updraft w/ rain-free base

Downdraft with rain/hail

Hays, KS

May 27, 2012

# Pop Quiz



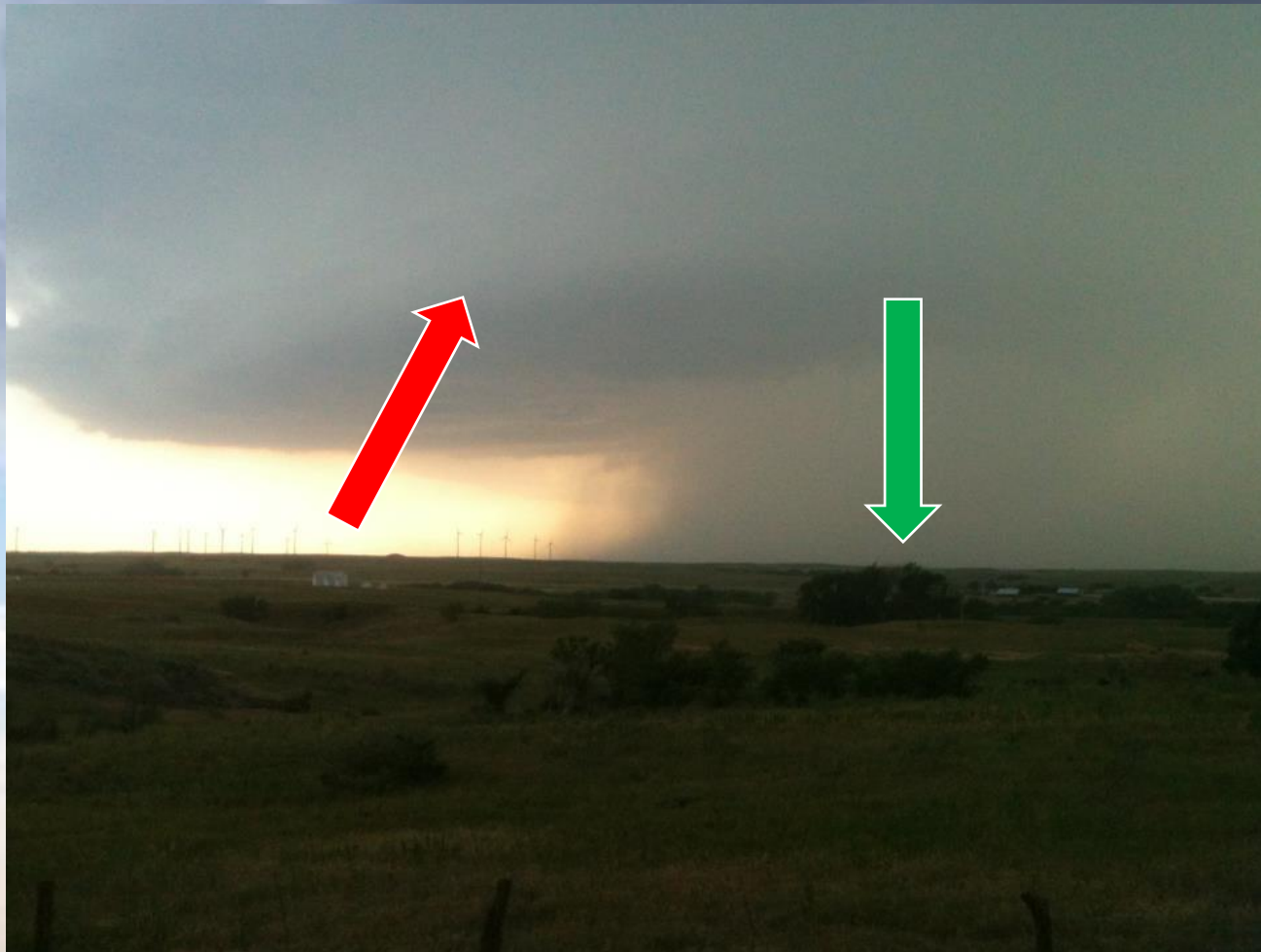
Find the updraft  
and downdraft

Wall Cloud

Wall Cloud is an  
area of lower  
cloud bases  
beneath the  
updraft

Hays, KS  
May 27, 2012

# Pop Quiz



Where is the  
updraft?

Where is the  
downdraft?

Elk City, OK  
May 19, 2012



# Pop Quiz



Scud

Rising air  
condenses to form  
small clouds  
being pulled into  
the updraft

Elk City, OK  
May 19, 2012

# Pop Quiz



Wall Cloud

Anadarko, OK  
May 19, 2011

# Pop Quiz



Find the updraft  
and downdraft

Mesocyclone

Adrian, TX  
May 21, 2012



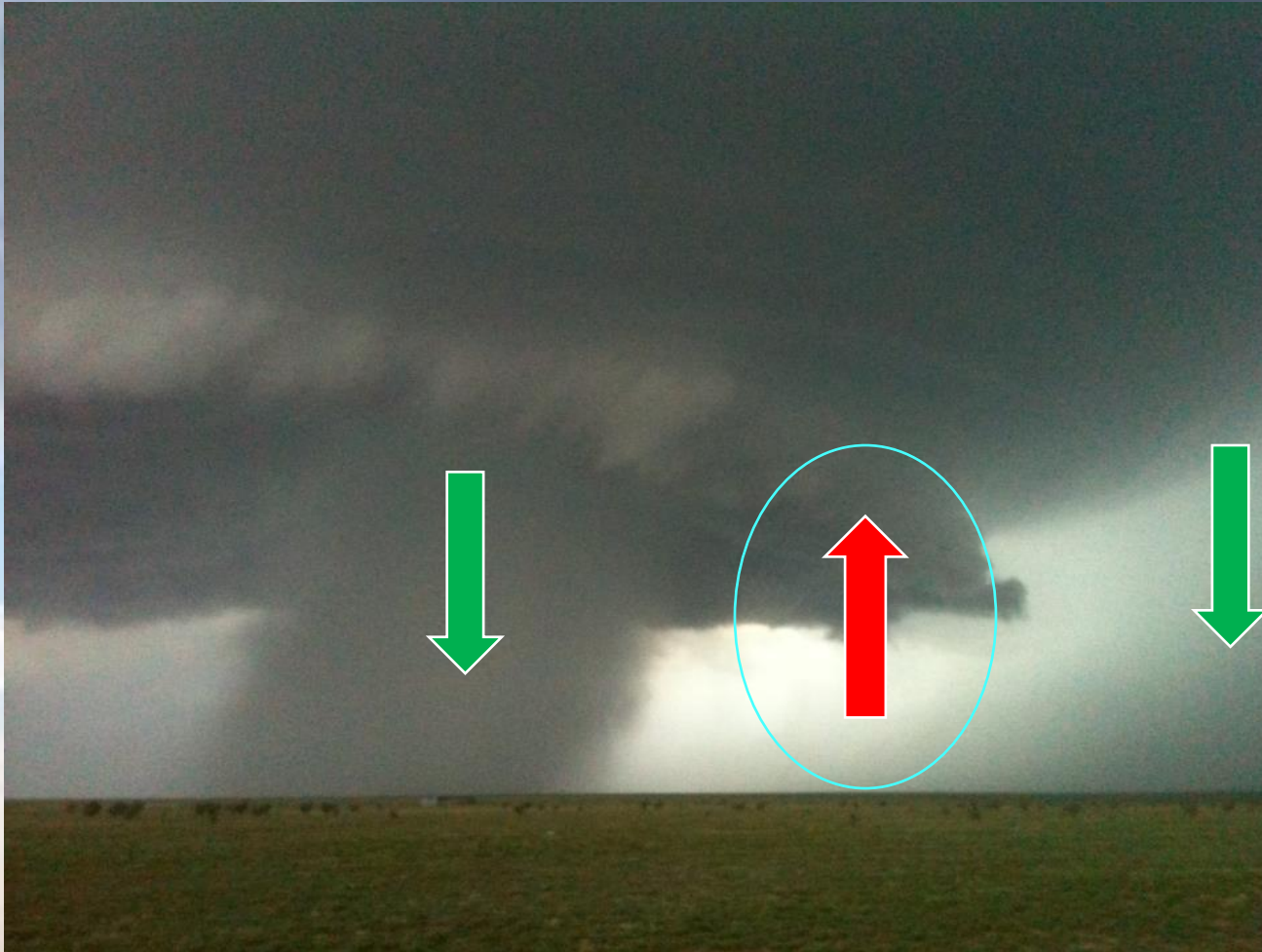
# Pop Quiz



Scud

Adrian, TX  
May 21, 2012

# Pop Quiz



Where are the  
updraft(s) and  
downdraft(s)?

Where would a  
tornado form?

Adrian, TX  
May 21, 2012

# Pop Quiz

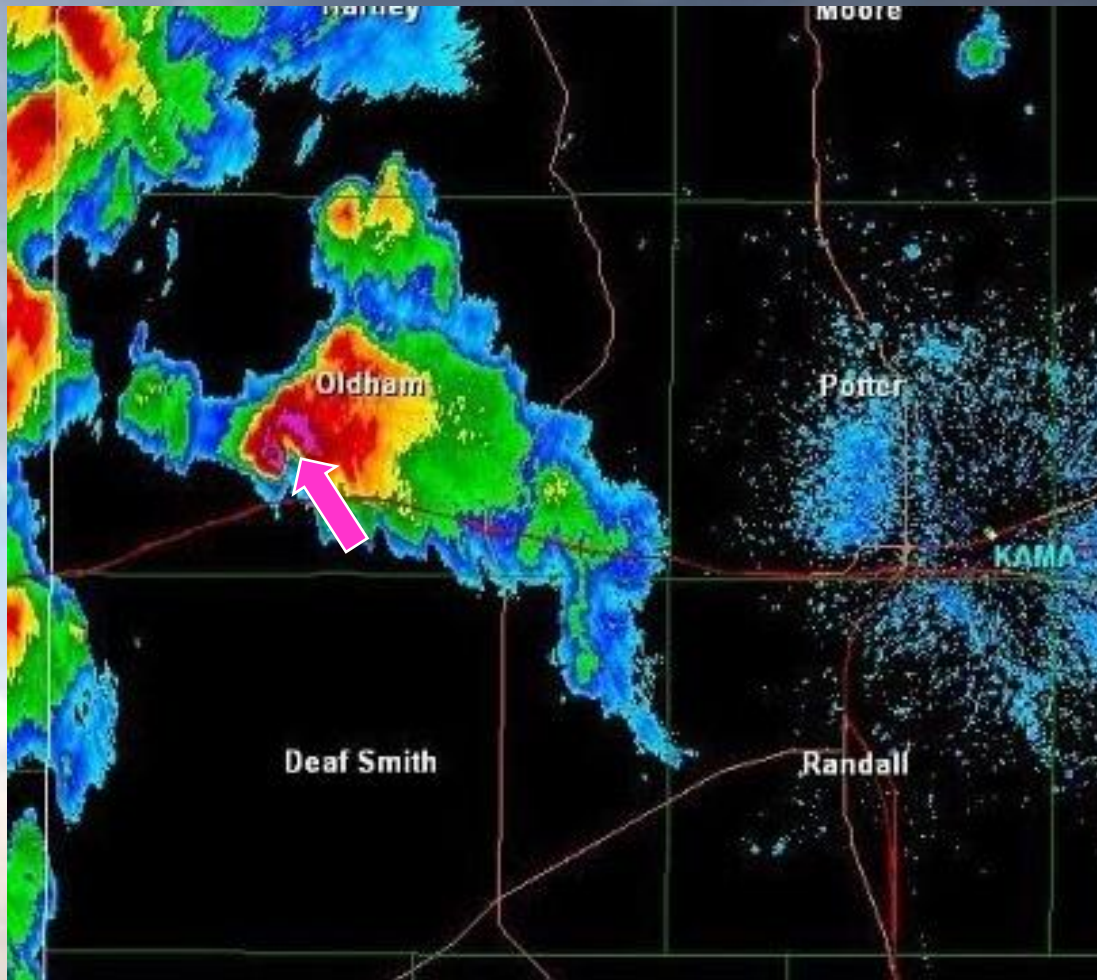


Funnel Cloud?  
Tornado?

Adrian, TX  
May 21, 2012



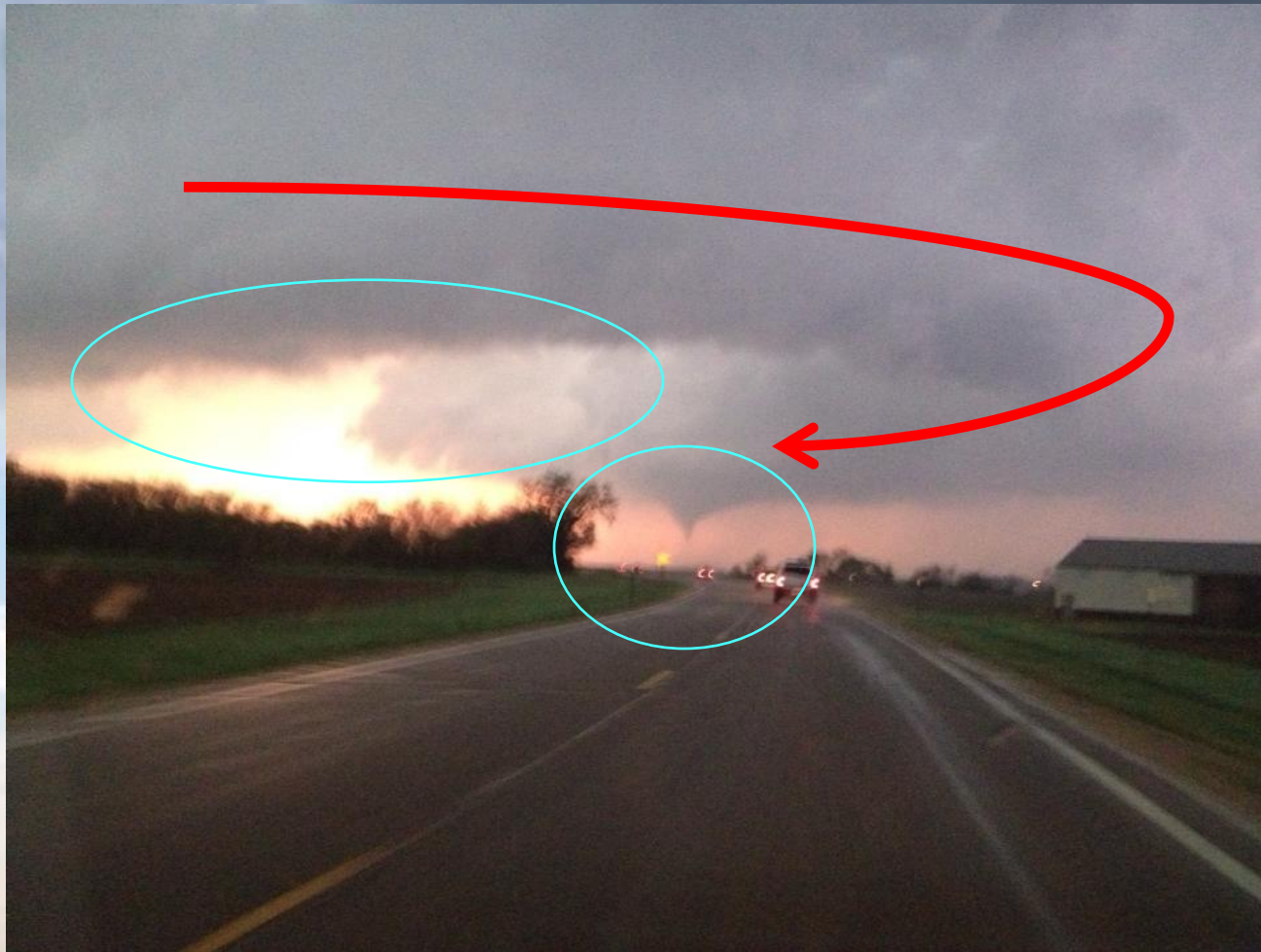
# Thunderstorm Review



Where would the  
tornado form?

Adrian, TX  
May 21, 2012

# Pop Quiz



Funnel Cloud

Rear Flank  
Downdraft (RFD)

Rozel, KS  
May 18, 2013

# Pop Quiz



Tornado

Rozel, KS  
May 18, 2013



# Pop Quiz



Funnel Cloud or  
Tornado?

Tornado

Rozel, KS  
May 18, 2013

# Pop Quiz



Wall Cloud

Purcell, OK  
May 30, 2013

# Pop Quiz



Scud

Purcell, OK  
May 30, 2013



# Pop Quiz



Funnel Cloud

Purcell, OK  
May 30, 2013

# Pop Quiz



Wall Cloud

Purcell, OK  
May 30, 2013

# Pop Quiz



Wall Cloud

Purcell, OK  
May 30, 2013



# Pop Quiz



Updraft/Downdraft?

Wall Cloud?

Funnel Cloud?

Campo, CO  
May 31, 2010

# Pop Quiz



Where would a  
tornado form?

Wall Cloud?

Funnel Cloud?

Campo, CO  
May 31, 2010

# Pop Quiz



Where would a  
tornado form?

Wall Cloud?

Funnel Cloud?

Campo, CO  
May 31, 2010



# Pop Quiz



Original circulation  
dissipates. New  
circulation takes over

Campo, CO  
May 31, 2010

# Pop Quiz



Find the tornado

Campo, CO  
May 31, 2010

# Thunderstorm Review



Find the tornado

Campo, CO  
May 31, 2010



# Summary

- The NWS has tools for detecting severe weather
- Only by combining the tools with skilled forecasters and spotters can we provide the best service
- Severe storms pose a variety of threats
- We all must be ready when storms threaten

# Questions? Contact Us!

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